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PORTO RICO AGRICULTURAL EXPERIMENT STATION,

D. W. MAY, Agronomist in Charge,

Mayaguez, P. R.

**Under the supervision of the STATES RELATIONS SERVICE,
Office of Experiment Stations, U. S. Department of Agriculture.**

**REPORT OF THE PORTO RICO
AGRICULTURAL EXPERIMENT
STATION.**

1918.

Issued September 17, 1920.



**WASHINGTON:
GOVERNMENT PRINTING OFFICE.**

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[Under the supervision of A. C. TRUE, director of the States Relations Service, United States Department of Agriculture.]

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LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., March 11, 1919.

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Porto Rico Agricultural Experiment Station, 1918.

D. W. MAY,
Agronomist in Charge.

DR. A. C. TRUE,
*Director of States Relations Service,
U. S. Department of Agriculture, Washington, D. C.*

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON, *Secretary of Agriculture.*

¹ Appointed Nov. 26, 1918, to succeed Phillip L. Gile, resigned.

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REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1918.

REPORT OF THE AGRONOMIST IN CHARGE.

By D. W. MAY.

INTRODUCTION.

During the year 1918, the station, while pursuing the outlined plan of previous years as regards research, has at the same time carried on considerable work along extension lines suggested by war necessities. It is needless to say that the research work was hampered and delayed to some extent, not only by the urgent demands of immediate food production but also by the calling of the employees of the station into war service. During the year several of the employees entered the Army, while others were transferred to work bearing more or less directly on war needs. As it was impossible to replace these men, it was necessary to carry on the work of the station on a restricted scale till the cessation of hostilities permitted the gradual resumption of normal activities.

The war has brought the people of Porto Rico to a realization of the needs of the island in improved methods and increased production in agriculture. The fear of isolation by submarine activities emphasized the importance of increasing food production by planting vacant lands and by interplanting food crops with the staple crops of the island. Importation of foodstuffs had become so general and their home production so limited that the threatened possibility of being cut off from sources of food supply disclosed the fact that a land of perpetual summer and a continuous growing season might be brought to face the problem of want and possibly starvation. This made the people of the island willing not only to plant and cultivate more land, but to seek new crops and to study the latest methods of improving yields and increasing profits.

Through it all the results of the station experiments have been studied and applied to a greater extent than ever before. Greater progress has been made in agriculture than in any other year of the island's history. Crops heretofore neglected have been taken up, methods formerly ignored have been applied, and unused lands and idle people have been employed in production to a greater extent than ever before.

SUGAR CANE.

Sugar as usual has formed the leading crop, and among exports has exceeded in value all other products. Owing to the unusually high prices brought about by economic conditions throughout the world, great efforts have been made to increase production by every available means.

During the year a serious disease of cane became noticeable, and it is giving grave concern. It appears to be a physiological trouble, and is evidenced by a yellowish or chlorotic appearance of the leaves and a shrinkage of the stalks, general characteristics very similar to those of the yellow striped disease of the East Indies. Studies and experiments are under way to combat it, and, while the outlook is serious, planters are alive to the situation and will lend every assistance possible in keeping the disease within bounds.

There is no doubt, however, that not only to combat disease but to conserve and improve the soils a more rational system of rotation must be followed by Porto Rican cane planters. At present, as the price of sugar is high, many cane growers have extended cane plantings to lands that under normal conditions would not produce sugar at a profit, and it is very difficult to get them to consider any other plan than that of planting good cane lands continuously to cane. Continued losses will induce most planters to plan a wise rotation and reasonable treatment of soils, based upon production through a series of years rather than upon the present market outlook for a single product.

FRUIT.

During the year there was a good production of fruit crops and a high average market, but shipping facilities were inadequate. Owing to the withdrawal of a number of ships for overseas service, the space available for fruit has been very much curtailed, with the result that considerable fruit has failed to reach a market.

Efforts have been made to utilize the fruit by-products. For some years a great many pineapples have been canned, but no use has been made of defective grapefruit and oranges. Many of the latter fruits, though sound and of good quality, are unmarketable because of over-size, unusual shape, or blemished skin. Through the efforts of the experiment station and the fruit exchange, the Bureau of Chemistry, United States Department of Agriculture, cooperated in the matter of trying out on a commercial scale methods of bottling grapefruit and orange juice as developed in the laboratory. The results have proved very promising, and the juices are now being placed on the market with assurances of success. Some work with marmalade is also in progress. The profitable utilization of the waste products of the citrus industry appears to be quite possible.

Groves that have been properly fertilized and cultivated are showing splendid results. On the other hand, groves not receiving proper attention are deteriorating and showing the usual signs of neglect. No other industry perhaps requires such constant and unremitting care as fruit growing. This is especially true in the Tropics, where there is no resting period in the year but where, as with the orange, the blossoms of the coming crop appear before the last of the preceding crop is gathered.

The most serious trouble to the citrus grower at the present time is scab. The station is devoting considerable attention to combating this disease, and with the cause known and considerable data accumulated as to methods of attack the outlook is favorable for overcoming it.

The station receives many inquiries from prospective planters as to the outlook for the fruit industry in Porto Rico. It is difficult to give a general opinion to fit all cases. In the first place the prospective planter should be sure that he will like the life. He should by all means make a visit to the island and learn something at first hand as to the conditions prevailing. Orange growing appeals to many men as an ideal occupation in which they can retire from the active pursuits of life and spend happy days easily picking golden fruits and profits with the least expenditure of effort. Though the difficulties that beset the fruit industry are not insurmountable, it brooks no neglect, requiring constant service, abundant capital before returns can be expected, and constant and unremitting attention always.

COFFEE.

By reason of the war prices for coffee were lowered and markets restricted. This, with a decreased yield, has been a great hardship to the coffee growers of Porto Rico.

The best market for Porto Rico coffee is still in Europe, though Cuba has taken increased amounts of the crop, especially of the better grades that have heretofore gone to Europe. Little progress has been made in selling the coffee in the States, nor is progress likely unless the coffee consumers there change their tastes. Porto Rican coffee is an after-dinner coffee of the highest type, while the great bulk of the coffee consumed in the States is drunk in large cups with cream and sugar where a certain aroma is the first requisite.

Very few new plantings of coffee are being made in Porto Rico, and the older plantings are giving decreasing yields. The industry is declining, and for both cultural and economic reasons it is not likely that it will again approach the position it once held in the island's industries. The soils once devoted to it are in need of a

change to other crops. As these lands are mostly steep, mountainous, and in some cases almost inaccessible, and as only hand labor can be used in the production and harvesting of the coffee grown on them, it is improbable that the industry can thrive in competition with the virgin soil and level lands of other coffee-producing districts where machinery can be used in all the processes of production. Moreover, the advantage given to perishable products in Porto Rico because of its nearness to the markets of the States does not obtain with coffee, which can be shipped from distant points without loss or deterioration.

Coffee will never be again the one crop of the plantations of Porto Rico. The main hope of the coffee grower lies in diversification. While securing such profits as he may from his coffee plantings, he should diligently seek other crops to occupy the idle lands of his plantation and to replace those now planted to coffee when the coffee trees deteriorate to the point where they fail to yield a profit. It is not probable that the coffee of Porto Rico will bring a price enough above that of Brazil to pay the larger cost of production, nor is it possible without expensive artificial manuring to secure yields approximating those of the early days of the industry.

FORESTRY.

Although the island has been largely denuded of its trees, mainly for the purpose of making charcoal, little effort has been made to reforest the areas devastated. There is, however, a growing interest in the matter of tree planting fostered chiefly by the schools. More extended and systematic planting of trees is much to be desired. The station has continued to send out trees and seeds of a few varieties considered of greatest economic importance because of their adaptation to local conditions and future needs and values. Besides the fruits mentioned in other parts of this report, the trees of most promise are the mahogany and eucalyptus, the former probably the more important as it thrives perhaps in a greater variety of situations than any other forest tree so far tried, is unsurpassed as a cabinet wood, and will always have a value, doubtless an increasing one, as the world supplies appear to be steadily diminishing.

On the 200-acre tract of land on the mountain above Mayáquez the work of reforesting has been continued. A number of introduced hardwoods are making good growth, and the trees are steadily extending their covering over the bare mountain side.

For the pasture lands, especially of the south or dry side of the island, the algaroba of Hawaii, introduced under the name *Prosopis juliflora*, is proving a very valuable tree. It affords shade for live stock, and being a legume, it improves the soil while the pods furnish a large amount of palatable food for animals. Its more extensive planting is being urged.

LIVE STOCK.

The improvement of live stock in the island is continuous but slow. The great increase in motor vehicles both for pleasure and for commercial use has caused a slowing up in production of horses and mules, and even the employment of oxen on the plantations and on the roads is decreasing.

The great desideratum of cattle raising is the elimination of the tick. The toll taken by this pest is enormous, and it is the great deterrent to the importation of breeding cattle, the most important feature of the upbuilding of Porto Rican herds. However, there is a general recognition of the importance of eliminating the tick, and following the example of the station, where the first dipping tank was built, the people are now constructing tanks in various sections of the island. When public sentiment and spirit is somewhat further aroused, a reasonable appropriation, backed by the use of the best methods employed in the Southern States, will quickly and easily rid the cattle industry of this scourge.

There is improvement in the pig and poultry stock of the island. Both can be best improved and increased by the greater production of local feeds for their maintenance.

AGRICULTURAL LABOR.

With the continuous increase in agricultural production, systems and methods of farming are changing, especially in the use of labor-saving machinery. The supply of unskilled labor also continues to increase more rapidly than the demands of profitable employment, this being particularly apparent in the interior where coffee has been the main crop. The production of coffee remaining fairly stationary or decreasing while the population of the plantations is steadily increasing, the life of the rural laboring population is hard and their opportunity for advancement practically nil.

The agricultural laborer is called a peon; he usually spends his whole life on the same plantation. The land may be sold but he remains. The owner, who employs the peon when there is work and money to pay the small wage customary, is in a way responsible for him during times of food scarcity and gives him permission to build his shack on the plantation and to cultivate food plants for his own use. The peon is a dependent and is content with a bare subsistence.

In view of the surplus of labor, and in view also of the fact that Porto Rico is one of the most densely populated agricultural regions of the world, having over 300 inhabitants to the square mile, the only way to meet the situation is to increase production. That the island is doing this is shown by the steady increase in value of exports from \$8,000,000 in 1902 to \$70,000,000 in 1918; but at the same

time the population has increased enormously. If the island is to progress, better food, clothing, housing, and education for the people are necessary.

REPORT OF THE HORTICULTURIST.

By T. B. McCLELLAND.

VANILLA.

Considerable progress was made during the year in the work with vanilla. A bulletin was prepared covering the main features of the investigations carried on with this crop in the last six years. A plantation has been established on a commercial scale near the center of the island, and a large nursery planted at the station for supplying cuttings, the scarcity of planting material being all that is retarding the extension of this crop at present. Investigations have included different systems of propagation, the effect of light and heavy pollinations, and different processes of curing.

As covered sections of vine often rot, aerial propagation was tested by simply tying cuttings to a support and leaving them wholly unconnected with the ground. These were under observation for eight months, by which time in most but not all instances roots had developed, this occurring any time after the first month. One aerial root had grown 40 inches in this period. Its maximum rapidity of growth exceeded 4 inches in a week's time. While roots were generally produced by cuttings so placed, their development was much slower than when several nodes of the cutting were covered with leaf mulch, but after the aerial roots entered the mulch the subsequent development of the cutting was entirely normal.

Very pronounced effects on the weight and length of the pod were secured in relation to heavy or light pollinations. The vines were classified in three groups in which, respectively, 2, 4, and 6 pods per cluster were allowed to develop. With the production of an increased number of pods, as shown by the averages for the three groups, there resulted a decrease in weight per pod but an increase in weight of total production, the fresh weight of the average pod being 16.8, 12.7, and 9.9 grams, respectively, for the three groups. The group in which only two pods developed per cluster averaged a greater number of pods per plant of 8 to 9 inches in length for each quarter-inch size than did the group in which 4 pods developed per cluster, while the same held true for the latter group in each length of $7\frac{1}{2}$ to 9 inches when compared with the group in which 6 pods developed per cluster. Individual plants produced pods to the equivalent of 2 pounds of cured beans.

The 1917 crop from a tenth-acre plat, with 42 vines in production, amounted to 36.44 pounds as marketed, occupied a trifle less than 1 cubic foot of space, and sold in New York at \$3 per pound, producing a gross return of \$109.31.

Two small seedlings have been secured from crossing S. P. I. No. 14441 ♀ with a distinctly different variety or possibly a different species, as represented by S. P. I. No. 14442 ♂. The more vigorous of the seedlings measured several inches in height at two years from planting and had by this time begun a thrifty growth (see Pl. I, fig. 1).

COFFEE AND CACAO.

Investigations with coffee have followed much the same lines as in former years.

The transplanting experiment with San Ramón coffee discussed in a publication² of the station continued to show by the past season's crop, three years after transplanting, a difference in favor of the group transplanted with roots incased in a ball of earth from the nursery, the crop from these trees being approximately 10 per cent greater than from the alternating rows, which were transplanted with their roots bare of earth. As this variety shows considerable variation in type after the third-year crop, the less desirable forms were discarded, to be replaced by seedlings from selected trees.

In the planting of *Coffea dewevrei* individual crop records are being kept on trees of special promise, this planting showing an extremely wide variation in type. The tree which has made the maximum growth and given the maximum yield produced in the past season at a little more than six years from seeding, 23.4 liters of coffee cherries. The cup quality of this variety does not equal that of the Porto Rican coffee, but it is fair.

In several cooperative fertilizer experiments on coffee plantations the 1917 crop showed no effect from nitrate of soda applied in varying amounts in February, August, and December, 1916. In a fertilizer test which has been carried on at the station now for eight years, the yield per tree for the past crop averaged 8.4 liters of coffee cherries for complete fertilizer, 5.7 liters for combinations of phosphoric acid or potash with nitrogen, and 2.8 liters for the combination without nitrogen and for the check plat. This is the third crop in which the yields obtained followed in the same sequence—that is, complete fertilizer, the two combinations carrying nitrogen and omitting either potash or phosphoric acid, the combination omitting nitrogen, and the check.

In last year's report an experiment undertaken in the control of the coffee-leaf disease (*Stilbella flavida*) is described. The treat-

² Porto Rico Sta. Bul. 22 (1917).

ment accorded this plat has given excellent results. At the latest inspection, a little more than a year and a half from cleaning out the plat, more than 400 trees were examined and less than 2 per cent of them showed any infection whatever. The infection found was slight and only on trees near the edge of the plat, where infection is always to be expected, as the plat is completely surrounded by diseased growth. That the plat, except on its border, has remained entirely free of this disease for this length of time, and that the trees are making vigorous growth clearly demonstrates the efficacy of the means employed for control of the coffee-leaf disease, which is very disastrous in its effects on coffee production at the higher altitudes.

In the older cacao orchard there has been a fairly steady increase in the annual yields for some years, reaching an average production of 32½ pods per tree for the calendar year of 1917. Provided the planter is able to prevent extensive ravages by rodents, which are very fond of the sweet pulp surrounding the seeds, this crop should come in for commercial consideration, as the returns in Porto Rico compare favorably with those of coffee. Interest in planting cacao is on the increase among coffee planters, and a considerable quantity of seed has been distributed from the station.

MANGOES.

Sixteen varieties of imported mangoes fruited this season, including two which had not fruited previously, *Mekongensis* and *Kistaphal*. Properly ripened fruits were not obtained of either of these, such fruits as were secured having dropped prematurely. Their quality was inferior to that of some others of the imported varieties.

Cambodiana, Amini, and Totafari were the most prolific producers. As the high quality of the Cambodiana makes it a general favorite, a knowledge of the character of the seedlings is most desirable. Of seven seedling trees which fruited four were seemingly identical with the parent, one exhibited minor differences, and two varied distinctly from the type, having decidedly more fiber and also differing in other characteristics. One of these had a considerably more rounded cross section than the typical Cambodiana, a slightly more highly colored skin, flesh a deeper yellow, flavor less acid with a trace of turpentine, and fiber up to an inch in length. The fruit was flattened on the dorsal side, and had a pronounced cavity at the base. The flavor was much liked by the individual who tasted this fruit. The seedling trees which varied from type do not include the one reported as fruiting last year, as this failed to fruit this season. The seedling trees of Cambodiana which have fruited show that while in propagation from seed no assurance can be had of securing a fruit identical with this parent variety; the chances are very good for the seedling

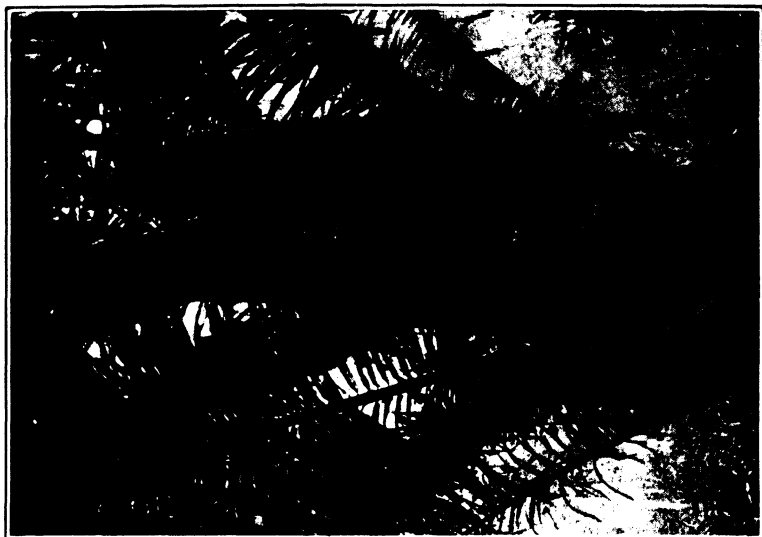


FIG. 2.—SUGAR PALM.

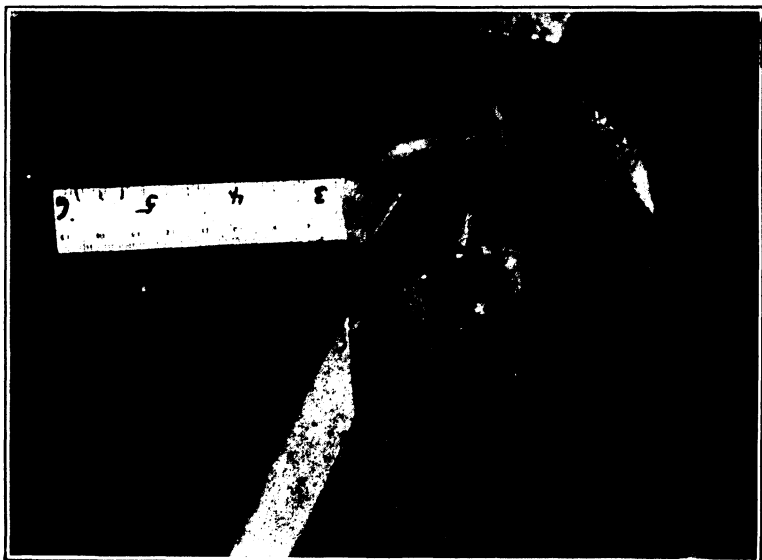


FIG. 1.—VANILLA SEEDLINGS TWO YEARS FROM SEEDING.



FIG. 1.—VARIETY TESTS OF BEANS.



FIG. 2.—*MUSSÆNDA PHILIPPICA*, AN INTRODUCED ORNAMENTAL.

either to be identical with the parent or, if different, still to retain a flavor of pleasing quality.

The grafted trees are being steadily increased in number in the station orchards and varieties which have proved of high quality are being distributed.

Drying mangoes was tried with success, the dried fruit keeping well for months. Some fruits were peeled and sliced, others were halved and left unpeeled, then placed in the sun for a number of days. The sliced mangoes in drying became exceedingly sticky to handle, but otherwise were more satisfactory than the unpeeled, halved mangoes. The flavor was quite distinctly different from that of the fresh fruit and the taste agreeable, but the appearance very unattractive.

BEANS AND PIGEON PEAS.

The initial planting of an extensive test of bean varieties was made on April 1 (Pl. II, fig. 1). This date is too late for an assurance of best results with beans in this section of the island. Growing conditions were excellent for six weeks, after which heavy and frequent rains flooded the planting to such an extent as to necessitate the harvesting of the immature crop at two months from planting. Nineteen varieties from the mainland of the United States were tested and in addition Santo Domingan, Venezuelan black, Porto Rican red, and Porto Rican white beans. The planting consisted of 60 rows. Blossoming dates, earliness, number of pods per plant, weight of pods, and weight of the shelled beans were recorded.

Mohawk was the earliest to develop pods of sufficient size for eating as green beans, while Porto Rican red, Dwarf Horticultural, and Currie's Rustproof Black Wax were also notably early. Porto Rican white and Venezuelan black beans were very late in blossoming. If single rows are considered, the six leading varieties ranked in descending order as follows in combined weight of pods and beans produced: Venezuelan black, Bountiful, Porto Rican red, Mohawk, Longfellow, and Full Measure. In weight of beans alone the order for the six leading rows was Venezuelan black, Porto Rican red, Bountiful, Extra Early Valentine, Six Weeks Round Yellow, and Mohawk; but if instead of single rows the average for rows of each variety is taken the order becomes Mohawk, Bountiful, Porto Rican red, Dwarf Horticultural, Six Weeks Round Yellow, and Extra Early Refugee. The poorest yields were from Stringless, Refugee Wax, and Round Pod Kidney Wax.

A second planting of 29 rows was made April 23 to test the different varieties under the less favorable conditions of the early rainy season. In this planting the Venezuelan black and Porto Rican red gave best results, followed by Hudson Wax and Porto Rican white

beans. The three most productive rows were of Venezuelan black, with the leading row producing about three times as much as the Porto Rican red and more than five times as much as any northern variety.

A third planting of 30 rows was made May 17 and a fourth planting of 28 rows June 18. In each of these plantings best results were had from Venezuelan black and Porto Rican white beans, showing that of the beans tested these varieties were best able to withstand the very unfavorable conditions produced by the heavy rains, under which many succumb entirely.

Simultaneously with the bean test a number of selected strains of pigeon peas are being tested, this being a crop which is generally planted without any selection whatever though marked differences are found in both pod and seed.

Plantings were also made of several noxious beans grown and sold in the island but these were destroyed by floods before fruiting.

MISCELLANEOUS INTRODUCTIONS.

In the test plat for miscellaneous introductions several plants may be mentioned as showing themselves well adapted to local conditions.

A number of specimens of *Flacourtia gardnerii* have grown into vigorous and prolific shrubs. The flowers are much liked by bees. The fleshy fruit, a flattened sphere about the size of a cherry, is a very dull red approaching black in color with a whitish bloom. The fruit is too acid a flavor to be enjoyed when eaten raw, and jelly made from it, though having a good appearance, is quite acid in flavor with a suggestion of saltiness which renders its quality very poor.

Uvaria rufa has grown well. The small, reniform, clustered fruits, shiny red in color and covered with a yellow down which gives them a somewhat artificial appearance, are rather ornamental. The fruit contains 8 or 9 proportionately large seed, each surrounded by a translucent pulp which adheres very closely. The flavor is mildly subacid and the quality poor.

Mussaenda philippica is a shrub of very striking appearance and one which would be effective in landscape gardening. One of the five calyx lobes of many, but not of all, blossoms enlarges into a petioled ovate leaf-like form, attaining in some instances a length of as much as $4\frac{1}{2}$ inches and a breadth of more than 3 inches. Its color is creamy white with a little green on the under surface. As this does not drop with the small orange star-shaped blossoms, this shrub remains a conspicuous object over a long period of time (see Pl. II, fig. 2).

Among other introductions which are growing well at the station is the sugar palm. (Pl. I, fig. 2.)

REPORT OF THE ENTOMOLOGIST.

By W. V. TOWER.

From data compiled from a questionnaire sent to the beekeepers of the island it appears that the beekeepers securing the most honey are requeening at least once in two years. Honey reports for the various districts have been compiled and averages worked out. A more detailed account of this work is given below.

Assistance in the storing and fumigation of food products was given to merchants on the island. One large commission house in Mayaguez has built a concrete fumigation room, designed by the writer, who carried on the first two fumigations. Other fumigation rooms should be built, as grains become more quickly infested with weevils in the Tropics than in a temperate climate where there are marked changes in temperature.

A number of inspection trips were made in the past three months to various citrus and cane plantations. The citrus crop for the island was found to be below normal, but most of the fruit was bright and free from rust and scale. Many of the growers have used formulas recommended by the station for scale and rust mite.

BEES.

There has been a falling off in the production of honey per colony for the last few years, which is attributed to the increased number of apiaries and colonies to a given locality. When the price of honey dropped at the beginning of the war, the beekeepers did not give their apiaries the care which they had previously given them.

There is a tendency among some beekeepers to requeen not oftener than once in three years. This is a very poor practice, especially in the Tropics. The queens have to work all the year round and become exhausted much sooner than in a colder climate. Queens should be changed every 18 to 24 months.

From replies returned to questionnaires it is apparent that the majority of the beekeepers on the island do not practice a systematic building up of their colonies for the coming harvests. The working force of bees should be built up to their highest strength just before the harvest begins. This can be accomplished by introducing young queens, as they are more active than the older ones and produce more brood. Careful manipulation of brood and judicious feeding help to produce strong colonies. The early removal of drone comb to supers is an excellent practice, and in its place full sheets of brood foundation may be inserted, or drawn-out brood combs may be given with even better results. Strong, young colonies have often been seen to store more honey than full colonies with old queens.

The apiarist should make a study of the flora of his locality, keeping a record of the honey flows in order to be able to bring his bees to full strength for the various flows. It is difficult to do this in Porto Rico on account of the irregularity of the various blooms, but

it can be done. At extracting, each hive should be credited with the number of frames of honey produced so that the beekeeper may know the colonies which fall behind and may also determine the colonies from which to breed.

CITRUS.³

The island's cultivated and wild crop of citrus for 1918-19 has been estimated at from 60 to 70 per cent of normal production, the present shortage being accounted for by the severe drought of the past winter and spring. The Manati and Barceloneta districts suffered most, as in many cases the early bloom dropped and the second, or May bloom, as it is termed, set poorly. The late bloom in many sections did not appear until June or July, and there was observed a heavy September bloom of oranges. The oranges and grapefruit blossomed very irregularly during the past year. The late blooms will mature in February and March, at which time the fruit should be bright and attractive.

The citrus growers of the island should raise more legumes in their groves to supply part of the nitrogen to the soil and also to prevent washing. These may be grown during the summer months when there is an excess of moisture. The crops should be cut in the fall and turned under. Working the grove at this time will, no doubt, hasten the ripening of the fruit. Care must be taken not to grow cover crops in the winter months unless there is plenty of rainfall, especially in groves that are producing fruit. The turning under of the various legumes not only adds nitrogen but puts the soil in better physical and mechanical condition, so that the fertilizers applied will be more readily taken up by the plant.

In a number of fruit districts central packing houses have been built, enabling the growers to bring together a greater quantity of fruit under one brand, to make a more uniform pack, and to reduce the overhead expenses. The growers who deliver their fruit to a central packing house have the advantage over those who pack their own fruit in that they can use their men during the packing season in their groves getting them in condition for the coming season. It also relieves the labor situation during the cane-cutting season, when it is so difficult in most districts to get men for the groves. Many planters who pack their own fruit have to give up all work in their groves during the packing season.

WHITE GRUBS.

Cane fields badly infested with white grubs should not be replanted for six months and the land should be plowed in the meantime. This gives an opportunity to thoroughly prepare the land. Such fields may be planted to cover crops between the time of cutting and planting, and such a practice would be beneficial to the coming crop. It

³ Since the transfer to the Bureau of Plant Industry of C. F. Kinman, former horticulturist, the entomologist has been in charge of the citrus projects of the station.

has been found that hogs and poultry following the plow consume great quantities of grubs. Birds should be encouraged to follow the plows. Bird boxes placed around cane fields would attract them at nesting time. Various leguminous trees may be planted near cane fields to attract birds so that they will nest and roost near the fields.

TICKS.

Owing to the work done by the former entomologist in his studies on tick eradication, the island is beginning to realize the importance of eliminating the tick. The extension office of the station at San Juan, in cooperation with the food commission, has started a campaign to eliminate the tick as far as possible. It is reported that some 60 dipping vats are to be built, which is a fine beginning.

MISCELLANEOUS NOTES.

Porto Rico can not be too strict in her plant quarantine regulations, as there are a number of very serious pests in countries near at hand which, if introduced, would completely ruin some of her industries. For instance, the Mediterranean fruit fly should be kept out, as it would mean ruin to the coffee, citrus fruit, and vegetable industries if established here. A new pineapple weevil has been found in Jamaica and should be guarded against. The depredations of the black fly in Cuba have caused that Government to appropriate \$50,000 for its extermination. The cucumber fly could be kept out, and citrus canker of the Orient and southern United States must be carefully watched.

REPORT OF THE ASSISTANT CHEMIST.

By J. O. CARRERO.

During the year further progress of the work planned in the chemical department was greatly curtailed by the resignation of the chemist, Mr. P. L. Gile.

A small amount of analytical work was done during the year, comprising mainly the quantitative analysis of plant ashes for three or four constituents, as well as the quantitative examination of various materials, such as manganese, copper, and iron ores; drainage and well waters; and dipping fluid from the station vats. Materials such as pyrites, manganese, and copper ores, and kaolin, which required only a qualitative test, were also examined.

Previous to his departure from the station, Mr. Gile brought to a close the work on lime-induced chlorosis.

Work on plant nutrition as affected by the number of roots in the nutrient supplied was also finished.

By far the largest share of time was spent in further studies of the relative efficiencies of the different phosphates in native soils.

The work progressed considerably during the year. Thus far nine soils have been investigated. Work on the last of the series planned is in progress and results on this last experiment will be obtained early next year. This work will include tests of bone meal, floats, slag, and double superphosphate in limed and unlimed soils when the fertilizer was added immediately before planting or several weeks previous to planting.

The attention of this department was called to the difficulty encountered in the bleaching of the Panama straw (*Cardulovica* sp.). Hats made from this straw are as light as those made from the native variety, they wear longer, and command a higher price in all markets, but owing to the difficulties met with in bleaching the Panama straw and the poor quality of the resulting fiber, it had failed to gain a foothold with native planters and weavers. The idea, therefore, was to evolve some cheap and easy method of bleaching which would be within everybody's reach and which could be successfully applied. This has been accomplished, and a very satisfactory grade of straw has been obtained at the station by the use of this method. It is still in need of some further investigation, straw being occasionally met with which is brittle and snaps in the weaver's hands. This may be due to two causes—too tender leaves being used or too thorough application of the treatment; but owing to the scarcity of material, it has not been possible to determine which of these is the exact cause of the brittleness in the dried leaves. It is expected, however, that as soon as some working material is available this objectionable feature of the prepared straw will be eliminated. Mr. Rafael Vidal, who is conducting fiber investigations for the Bureau of Plant Industry of the United States Department of Agriculture in cooperation with the station, gave valuable suggestions and assistance in the prosecution of the work.

REPORT OF THE ASSISTANT IN PLANT BREEDING.

By W. P. SNYDER.

This department has little work to report for the past year, owing to the fact that the writer was on leave in military service after February 1, 1918.

A second planting was made of varieties of Indian wheat in November, 1917, but the planting was badly injured by the changa and no record of yields was obtained. A former planting, made in the spring, was largely a failure on account of wet weather during the ripening period. Some of the varieties merit further trial, which should be made during the dry season.

Selections from several varieties of beans, made in the spring of 1917, were planted in December of that year, and these plantings were harvested and subsequent plantings made by the horticultural department. Two distinct strains of the black Venezuelan bean have

been found, one characterized by very dark green foliage with dark red stems and leaf veins, the leaves having a smooth, regular surface, while the other strain shows a light green color both on stems and leaves, usually with complete absence of the reddish markings, and has crinkly leaf surfaces. Several selections made from both strains have shown considerable variation in yield, some being very productive. Plantings of unselected seed of the black Venezuelan bean have proved consistently more productive than similar plantings of native, Santo Domingan, and mainland varieties.

Ten varieties of tomatoes were planted on September 15, 1917, and set in the field in early December for the purpose of making a variety test and for experiments in crossing certain varieties. However, with the limited amount of time available for the work, no crossed fruits were obtained. The crop was harvested and yields recorded by the horticultural department. The planting consisted of 32 rows of 25 to 30 plants each. The plants were trained to stakes and pruned to about three main branches. The following is a condensed record of the harvest:

Results of variety test of tomatoes.

Variety.	Number of rows planted.	Date of ripening of first fruit.	Average number of fruits per plant.	Average weight of fruit per plant.	Average weight per fruit.
				<i>Pounds.</i>	<i>Pound.</i>
Trophy.....	1½	Jan. 23	17.9	4.35	0.24
Carter's Sunrise.....	10	Jan. 17	23.9	2.33	.10
Red Pear.....	1½	Feb. 23	119.4	2.32	.02
Crimson Cushion.....	½	Feb. 16	5.5	2.21	.40
Lorillard.....	11	Jan. 20	12.4	2.06	.17
Native tomato.....	½	Mar. 2	19.2	2.05	.11
Ponderosa.....	4	Jan. 18	4.3	1.81	.42
Stone.....	1	Jan. 28	7.6	1.81	.24
Bonny Best.....	1½	Jan. 30	8.0	1.55	.19
Earliana.....	1	Jan. 9	5.9	.85	.15

Plans for the present year include, in addition to the continuation of lines of work already begun, the raising of seedling canes, variety crossing, and bud selection with grapefruit, and experiments in the production of vegetable and flower seed.

The mottling disease of sugar cane is proving very destructive to the commercial varieties now grown, and one of the most imperative needs of the cane industry in Porto Rico is the control of this disease. Varieties of sugar cane are quite variable in their susceptibility to the disease, and it is with the hope of producing a profitable resistant variety that the work of raising seedlings is undertaken.

Two methods of improving grapefruit varieties are planned; budwood selection based on records of tree performance and crossing of the Duncan and Triumph varieties. The latter method, while requiring a greater length of time and being more uncertain, has the advantage of giving a much greater variation of types from which to select than the asexual method of propagation.

Porto Rico is handicapped at present by the necessity of securing many vegetables and flower seeds from the States. Experiments will be undertaken to determine the possibility of producing such seed in the island during the dry season and to compare Porto Rican grown seed with seed from the States.

REPORT OF THE SPECIALIST IN FARM MANAGEMENT.

By H. C. HENRICKSEN.

INTRODUCTION.

The emergency food-production work in cooperation with the Food Commission and the Department of Education was continued during the year. While the chief aim was to increase the production of food crops during the war, it was found possible also to collect many data that will serve as a basis for future investigations.

An assistant engaged by the station and others of the staff—38 men—were employed by the Food Commission and the Department of Education.

As a direct result of the year's work, 1,160 agricultural committees were formed by July 1, 1,741 agricultural meetings were held, and 500 field demonstrations were conducted. The demonstrations were along the following lines: How to improve worn-out land by growing leguminous cover crops; how to obtain larger yields by certain preparation of the soil; the difference between good and poor cultivation; the value of manure and compost and how to make the latter; the right way compared with the wrong way of planting different crops, and the value of seed selection. Field experiments were conducted with a few crops, where there appeared to be an immediate necessity for certain data.

Potatoes were planted in 30 different localities with the object of finding the best-adapted varieties and whether or not this crop can profitably be produced. The seed used for the first series of experiments was bought in the open market from a lot imported from Spain. Four varieties were ordered from the States, but did not arrive on account of traffic congestion. It then became necessary to plant such potatoes as could be bought, regardless of variety. For that reason no data were obtained on varieties except that the American-grown potatoes seemed very much better adapted to Porto Rico than the Spanish. The yields reported were very variable, and more work along that line will be needed. It is worthy of mention, however, that the planting of these plats created an interest among the people and many acres were planted in localities where the cultivation of the crop was previously unknown. Only a few scattered small plats of potatoes had been grown in the mountains in former years, but this year 760 acres was planted, and the results were so encouraging that a large increase is predicted for next year.

Soy beans were distributed for trial in all municipalities and the yields reported were uniformly good. It is doubtful, however, whether plantings will be continued, as the value and use of the bean is not well enough known in the island. The pinto bean was introduced and tried, especially in the drier districts. The first trials did not give striking results, but plantings are being continued.

Notes were obtained on many other crops, such as Sudan grass, peanuts, castor beans, etc.; and the data are available for further investigations.

TICK ERADICATION.

A vigorous campaign for exterminating the cattle tick was conducted. Plans were outlined for the number of dipping tanks needed for the island as well as for an organization to conduct the work. It was estimated that the tick could be exterminated at a cost of approximately 50 cents per head of live stock infested. On account of the high cost of materials, systematic work was deferred until after the war, but as a result of the propaganda 10 tanks have been built by private or cooperative effort and 80 additional tanks have been promised.

AGRICULTURAL STATISTICS.

An efficient statistical service has been built up. The difficulties usually encountered when starting such work were gradually overcome and the data are now well within the limits of probable error.

Special attention was given to the 10 main food crops, as shown in the following table:

Acreage planted to 10 important food crops during 1917-18.

Crop.	September. ⁴	October.	November.	December.	January.	February.
Red beans.....	7,626	3,849	3,150	2,783	2,250	4,476
White beans.....	12,345	4,262	2,632	2,840	2,307	3,289
Cowpeas.....	6,515	2,200	566	343	446	708
Pigeon peas.....	13,455	3,194	859	827	682	1,670
Corn.....	36,923	9,456	1,812	926	981	4,141
Rice.....	12,009	2,201	410	93	32	211
Sweet potatoes.....	28,596	8,005	4,157	3,035	2,539	3,798
Yautias.....	9,977	2,449	917	930	970	1,868
Cassava.....	5,723	2,428	1,152	855	764	1,192
Yams.....	3,423	1,067	419	555	714	1,011
Total.....	136,572	39,111	16,074	13,187	11,775	22,354

Crop.	March.	April.	May.	June.	Total.
Red beans.....	7,922	9,583	7,977	1,500	51,116
White beans.....	6,042	9,458	7,356	1,906	52,527
Cowpeas.....	1,212	1,910	2,268	947	17,115
Pigeon peas.....	2,999	4,875	3,527	2,009	34,077
Corn.....	11,239	16,197	16,595	5,307	103,577
Rice.....	902	2,504	5,868	3,344	27,664
Sweet potatoes.....	4,055	4,788	5,749	5,322	70,044
Yautias.....	2,781	3,428	3,036	1,706	28,052
Cassava.....	1,326	1,739	1,875	1,250	18,304
Yams.....	973	1,305	888	327	10,682
Total.....	39,451	55,877	55,139	23,618	413,158

⁴ Planting up to September.

Two sets of data were tabulated monthly, one showing the acreage planted in each municipality during the previous month and another showing the probable yields to be harvested during the current month. The latter estimates were at the beginning based upon average yields for the whole island with deductions according to reports on crop conditions during the growing season. This was found to be incorrect by reason of the fact that the average yields were not correctly reported. Average yields are now being worked out for each municipality by actually weighing the crops from a large number of measured areas. These averages from a municipality are then being used as a basis of estimates for that municipality only. This work is not yet completed, but the figures will be very valuable as comparative data a few years hence.

The following crops were reported upon once during the year :

Amount of five important crops planted in season 1917-18.

Bananas	-----plants	41, 514, 806
Plantains	-----do	7, 617, 397
Coconuts	-----trees	736, 091
Potatoes	-----acres	760
Peanuts	-----do	340

The main crops—sugar, coffee, tobacco, and fruit—are not included partly because other agencies are gathering the statistics.

Number of live stock in Porto Rico in January, 1918.

Cows	-----	106, 951
Bulls	-----	121, 849
Calves	-----	94, 601
Horses	-----	62, 463
Mules	-----	9, 154
Pigs	-----	102, 176
Goats	-----	48, 930
Poultry	-----	970, 598

The above table shows the total for the island, but the tabulation was made for each municipality. The figures are believed to be correct within the limit of probable error in such work, with the possible exception of poultry.

PUBLICATIONS.

The following publications were prepared in Spanish, mimeographed, and sent to all agricultural agents, agricultural committees, school supervisors, agricultural teachers, and individuals especially interested:

LECTURES.

- No. 1. Feed Your Soil if You Want it to Feed You.
- No. 2. Increase Production.
- No. 3. Gardening.
- No. 4. Seed Selection.
- No. 5. Potatoes.
- No. 6. Bat Guano as a Fertilizer.
- No. 7. Kill That Tick.
- No. 8. Poultry.

CIRCULARS.

- No. 1. Storage of Grains.
- No. 2. Sudan Grass.
- No. 3. Velvet Beans.
- No. 4. Peanut Butter.
- No. 5. Soya Beans.
- No. 6. Castor Beans.

CHARTS.

- No. 1. Imports, 1917.
- No. 2. Exports, 1917.
- No. 3. Planting Table.

POSTERS.

- Kill That Tick.

REPORT OF THE AGRICULTURAL TECHNOLOGIST.

By W. A. MACE.

The work along various lines of extension begun by the writer last year were continued, and considerable progress has been made. However, more attention has been given to investigational than to demonstration work during the present year. This statement holds true for the work carried on in different parts of the island as well as for that which has been done at the station. The work on the various demonstration plats planted on the island was so conducted as to permit a study of the numerous problems encountered with the different crops. During the first part of the present year a good deal of time was spent in the fields of the corn district instructing the planters in the selection of seed corn. Much interest was displayed by the farmers, and a good quantity of seed was secured for the next planting.

A great number of Farmers' Bulletins and other agricultural publications were distributed among the farmers, where it was deemed that they would be appreciated and studied. Quite a quantity of seeds and plants was also distributed. Farmers in the vicinity of the station were allowed to dip their cattle in the station's dipping tank for destroying the cattle tick. Many took advantage of this opportunity and as a result were much pleased to see their cattle increase in weight, give a higher milk yield, and show a general improved appearance. It is hoped that this is the beginning of an organized campaign for the eradication of a pest which causes great losses to the cattle industry of the island.

The investigational work at the station has been with rice, beans, soy beans, corn, and forage crops, the greatest effort being with rice, covering variety tests and date of seeding. The work with the other crops is that of testing different varieties by comparison. In this work 3 varieties of corn, 9 of soy beans, 4 of field beans, 7 of cowpeas, and about 150 of rice were used.

During the last year five unsuccessful attempts were made to inoculate the soil at the experiment station with nitrogen-fixing bacteria for soy beans. In April of this year some pure cultures of

these bacteria were received from the United States Department of Agriculture and were successfully used, almost all roots of the plants being literally covered with nodules.

Though in the field work much greater efforts have been expended on rice than on any of the other crops, some plantings have been made of soy beans for variety tests and for demonstration, and of field beans and corn for testing rates of seeding and cultural methods. In the rice work, about 130 acres have been planted in fields, varying from 1 to 20 acres in size, in different parts of the island, altogether 16 field plantings being made. One field was used for increasing the seed of several varieties. Two small plantings were made on hillsides for comparing the pure-bred seed with that of the native rice grown in Porto Rico. In the other fields studies in preparation of the seed bed, rate of seeding, depth of planting, and several phases of irrigation were made on plats varying from $\frac{1}{2}$ to 1 acre in size. For this work the experiment station purchased a seed drill, reaper and binder, thrashing machine, and milling outfit for demonstrating the handling of this crop on a commercial scale. The rice grown on this island heretofore, with a single exception, has been in small hillside plantings where the work of the entire crop from planting to milling, inclusive, was done by hand.

Owing to the unevenness of the ground, which was in most cases old cane-field land with ditches and high beds, it was impossible to get the land leveled down properly. This made it impractical to submerge all of the land without getting too great a depth of water in some parts. For this reason what would seem to be maximum yields will not be secured, though some of the fields will give very good returns. The hillside plantings made by the station are showing up decidedly better than the native varieties which were planted at the same time under the same conditions. The work as a whole is sufficiently promising to warrant a continuation of the investigation with this crop, as it promises to be of considerable profit. It is confidently felt that this crop can be used in a system of rotation with beans and cane for conservation of soil fertility and for control of plant diseases and insect pests, and that it can be grown on vast areas which are now lying idle because they are too wet at certain seasons of the year for a long-season crop like cane, but which, if planted to a short-season crop like rice during the time when the rainfall is not so heavy, could be made to produce a successful crop by controlling the water for flooding the fields. A very important fact in this work is that the Porto Ricans are a rice-eating people, and rice should, therefore, be produced on the island as one of the principal crops.

The work of the station with rice has been carried on in cooperation with the Office of Cereal Investigations, United States Department of Agriculture, C. E. Chambliss, of that office, having made two trips to Porto Rico in supervising the work.

DEC 13 1920

PORTO RICO AGRICULTURAL EXPERIMENT STATION,

D. W. MAY, Agronomist in Charge,

Mayaguez, P. R.

**Under the Supervision of the STATES RELATIONS SERVICE,
Office of Experiment Stations, U. S. Department of Agriculture.**

**REPORT OF THE PORTO RICO
AGRICULTURAL EXPERIMENT
STATION.**

1919.



Issued October 15, 1920.



**WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1920.**



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PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director, States Relations Service, United States Department of Agriculture.]

E. W. ALLEN, *Chief, Office of Experiment Stations.*
WALTER H. EVANS, *Chief, Division of Insular Stations,*
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LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION.

Mayaguez, P. R., December 15, 1919.

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Porto Rico Agricultural Experiment Station, 1919.

Respectfully,

D. W. MAY,
Agronomist in Charge.

Dr. A. C. TRUE,
Director, States Relations Service,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.

A. C. TRUE, *Director.*

Publication authorized.

E. T. MEREDITH,
Secretary of Agriculture.

¹ Appointed Feb. 28, 1920.

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REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1919.

REPORT OF THE AGRONOMIST IN CHARGE.

By D. W. MAY.

INTRODUCTION.

The experiment station in Porto Rico continued to devote its energies to solving the most pressing food problems which arose as an outcome of the war, and most of its major work consisted in finding ways and means to increase the supply of food needed for home consumption. The menace of a scarcity of staple imported foodstuffs was keenly realized, especially during that crisis when one of our largest ships was sunk by a submarine, and as a consequence lessons in conservation and in the home production of hitherto imported foodstuffs were very welcome. It is believed that as a result the production of home-grown crops will become more of a fixed habit. The work of the extension division was continued under favorable conditions, and it has been shown that a wide range of crops can be grown in Porto Rico with considerable profit to the producer.

During the twenty years of the American occupation in Porto Rico agricultural production has increased tremendously, due principally to the development of large areas as single units. There seems to have been little or no departure from this tendency, despite the fact that efforts along educational lines and through legal enactments have been made to curtail large land holdings. Instead of cutting down large holdings, they have actually been increased through purchase or under long leases.

The manufacturer of sugar requires a large capital if he would profit by foreign trade. The coffee planter, on the other hand, often has other industries to fall back on financially. He is therefore better able to finance and export his products. A fruit growers' association has been formed to market the fruit, secure shipping facilities, and to handle by-products at a profit. These facts serve to prove that there is a tendency among agriculturists in Porto Rico

to combine into large units, either by purchase or lease, or by combinations to standardize and stabilize grades and markets and to buy and sell cooperatively.

Life in the Tropics is comparatively easy. The small cultivator is, as a result, usually more or less indifferent to anything other than obtaining a bare subsistence. No doubt in many lines he can produce more at a less cost than the larger planter, for his overhead expenses are much lower. On the other hand, the large planter or manager of a corporation thoroughly studies his business, and, although the actual cost of his production may be higher, his return is greater and nets him a quicker gain over cost.

Throughout Porto Rico the trees have been cut from the land, and the soil has been much depleted by persistent agricultural practice which considers only present profits. Sugar and coffee have been the leading crops of the island. Sugar continues to lead, this industry having been fostered since the American occupation by a protective tariff. Coffee probably has reached the summit of its importance as an industry and is on the decline. Unless aided artificially, Porto Rico can not produce coffee in competition with other countries.

Tobacco growing is attaining a greater success, not necessarily through larger production but through improved methods of curing and by reason of the fact that a large percentage of the population is skilled in cigar making.

Fruit growing, an industry introduced since the American occupation, is rapidly developing and gives promise of becoming the leading industry in the course of time. Fruits closely rival coffee and tobacco for second rank in exports, and with sugar now form the great bulk of the cargoes exported from Porto Rico.

SUGAR.

The exports of sugar vary from year to year with the prices. When the price of sugar is high, lands which ordinarily remain idle and unprofitable are planted to sugar cane. When prices fall, these lands go back to pasture. The area planted to sugar cane in Porto Rico is relatively large at the present time of high prices.

A threatening cloud is always on the sugar horizon. Just now it is the so-called mottling disease, having the appearance and habit of a mosaic disease. This has greatly reduced the production of sugar in some sections of Porto Rico. Fortunately, however, some varieties of cane are wholly or partially resistant. Among these is the Kavangire, which, since its introduction by this station several years ago, has been widely distributed over the island. (Pl. I, fig. 1.) This cane, though immune, is not of high quality. It stools well, but the stalk is of small diameter, and its fiber content and cost of

harvesting and milling run high. The Kavangire averages about 12 per cent sucrose and 80 per cent purity.

Some other and better varieties of seedling canes, while not wholly immune to the disease, not only are not seriously damaged by it but make a good growth in spite of it. By the use of these varieties and by frequently changing the seed and eliminating diseased stools, this disease can be controlled and perhaps exterminated. Considerable work has been done to determine whether the disease is borne by an insect. Up to the present no evidence has been secured to prove this to be the case.

The station again urges the employment of a more rational system of rotation in cane growing, and the use of other crops, especially a legume, in the cycle.

FRUITS AND VEGETABLES.

The fruit industry, developed since the American occupation, has had a precarious career. Fruit growers have come from all walks of life, many desiring homes where the outdoor life, plants, and the climate appealed to them, and others representing companies organized in the States to seek a profit. Others, again, were promoters and adventurers from whose operations the island and the fruit interests will not recover for years to come. The growing of fruit is precarious and requires constant and unremitting attention. The gains accruing therefrom are sometimes large, yet losses from unforeseen causes must be continually fortified against. In Porto Rico the growing of fruit has been a pioneering industry, and the experience gained in other countries has proved of little or no value to the fruit grower in Porto Rico. A number of groves are now producing well, others only small amounts, and many are complete failures.

Porto Rico is now in the second stage of the industry. Since necessity is driving them into organization and cooperation, the producers are thrashing out the problem of successful marketing. The Fruit Exchange, the first cooperative organization among the people, has been in operation for several years, though it is experiencing the various vicissitudes that beset all such endeavors.

The third stage in fruit growing now receiving attention is the utilization of by-products. Bottled grapefruit juice is now on the market and is being favorably received.

CITRUS FRUITS.

Little was done on citrus scab owing to the fact that the station was without a pathologist during the greater part of the year. Observations on this disease and its progress, however, are being made. It seems to be more prevalent where the leaf growth is greatest, and in groves which are hidden from the sunlight until late in the morn-

ing. Other studies now being made are those of the thrips which are found on the leaves, the influence they exert, and the probable damage caused by them. Cover crops for citrus plantations are receiving considerable attention, especially the more luxuriant kinds, such as velvet bean and *Crotalaria*, which, in addition to storing nitrogen in the soil, provide sufficient growth for humus and for mulching. Mulching as a substitute for cultivation is being tried out with some interesting results. Experiments conducted to determine the effect of fertilization on citrus trees are also receiving considerable attention. The matter of testing windbreaks for citrus trees continues to be one of much importance, and a number of additional species of trees are under trial for this purpose. These are leguminous trees, which are proving far more valuable than bamboo and trees of other orders. Records are being kept of citrus trees growing on a number of plantations, and fruit growers are being urged to secure budwood from the best bearing trees and to propagate these trees.

MANGOES.

Returns are beginning to come in from the hundreds of improved mangoes sent out by the station. These fruits are now found in the markets of the island and some shipments of them are beginning to go to the New York market. Several more of the new varieties of mangoes fruited during the year. The station is planning for the standardization of this fruit and for the extended propagation of the more promising varieties.

AVOCADOS.

The growing of avocados is steadily increasing, and the station has under trial a number of varieties which are well suited for shipping purposes. A great deal of this fruit is sold in Porto Rico, and it has been a mistake not to greatly increase the business of exporting it. To that end the station is working along two lines: First, to grow varieties that will stand shipping; and, second, to develop shipping methods which will enable the fruit to reach the mainland markets in good condition. Unfortunately, at present, refrigeration methods are lacking on ships, and until that deficiency is remedied the station will be unable to ship the native avocados even though they are of excellent quality. With improved shipping facilities and the development of better methods for preserving foods while in transit, avocado growing is destined to become an industry of considerable importance.

YAMS.

Introduced varieties of yams, which have proved of value, have been distributed in 75 municipalities of the island.



FIG. 1.—KAVANGIRE CANE. RESISTANT TO MOTTLING DISEASE.



FIG. 2.—DAIRY CATTLE PASTURING AMONG MAHOGANY TREES 13 YEARS OLD.

COCONUTS.

Regions devoted to the growing of coconuts have been extended, and the trees grown on the low, sandy beach lands, which are best adapted to this purpose, are already bearing. It has been found also that coconuts can be produced at a profit on certain lands away from the sea. The many uses to which the coconut can be put are increasing from year to year. This fact, in conjunction with that of the very little trouble and expense involved in the growing of coconuts, forms splendid inducements to further the planting of the coconut palm. A fertilizer test that has been in progress for four years with young palms has carried them to the time when the plants are just beginning to blossom. Older trees of which individual records have been kept are now yielding results.

CACAO AND COFFEE.

Individual records of cacao trees are being continued. The station has also under trial a number of the best varieties of cacao from other countries.

Fertilizer, variety, and pruning tests with coffee have been uninterrupted. Varieties of shade trees not locally used are also being tried out for coffee. In general an improvement in yield in coffee has been noted as the result of better cultivation and pruning. During the war period, prices of coffee in Porto Rico were low, though those of almost all other crops increased. At the present writing, however, a change is taking place, and better prices are being paid for coffee. Prices are steadily rising, and the indications are that a very large crop will be produced during the present season.

VANILLA.

Work with vanilla is showing excellent results. During the year a comparative test with different chemical and organic fertilizers was begun. Records are being made of the effects of pod production on the yield of vanilla beans, and on the yield of succeeding crops from the same plant. A number of processes for curing vanilla were tested, and various striking differences in the appearance of the cured beans and in the development of vanillin crystals were noted. Numerous vanilla cuttings supplied to different planters are now under trial in various sections of the island. The plantings are from 1 to 10 acres in extent, and indications are that vanilla will become one of the standard industries. The station considers vanilla especially valuable as an aid to coffee growers, as it not only gives them an additional profit from their plantations but also assures them of a yearly income.

ORNAMENTALS.

The introduction, propagation, and distribution of various plants of ornamental value have been furthered. Although the work of the station has been heretofore mainly along economic lines, the point has at last been reached where more attention can be given to the cultivation and distribution of ornamentals. Porto Rico is becoming more popular as a winter resort, and its many natural attractions should be improved.

RICE, BEANS, AND CORN.

A great deal of attention has been given to the cultivation of rice, and strong efforts have been made to induce the planters to grow more of this food, which is Porto Rico's greatest import. The food of the Porto Rican consists largely of rice and beans. Though beans are now grown in sufficient quantity to supply local needs, there is a necessity for growing more rice. Moreover, many of the lands which now produce cane should be thrown into some system of rotation. Rice promises to be one of the best plants for this purpose, as it not only improves the soil but also produces a crop of considerable value and one that should yield a profit.

Tests of the comparative productiveness of various garden and field beans and pigeon peas are under way, and a number of these legumes have been distributed throughout the island. Much attention has been given to the growing of Lima beans and especially to testing some which contained considerable amounts of hydrocyanic acid. In this connection some work has been done in cooperation with the Bureau of Chemistry, United States Department of Agriculture, and as fatal poisoning in the island has resulted where certain varieties of Lima beans were eaten information regarding the identification of these varieties has been disseminated.

Besides the better known kinds of beans, the station is endeavoring to promote a great increase in the growing of soy beans. This bean is especially valuable, as it is very rich in fat, that element being too frequently lacking in amount in the dietary. The growing of soy beans promises to be quite successful. Cowpeas are also being grown in increasing amounts. Some introduced varieties of the station are especially popular. The mung bean of the Philippines has been introduced and is gaining in favor. It grows under very adverse conditions, improves the soil, and makes a very nutritious food. A great deal of work has been done in the improvement of corn. The station has found that the best way to improve the corn crop is to develop some of the acclimated varieties.

LIVE STOCK.

Live stock is increasing in numbers and especially in quality. Purebred sires are imported each year from the States, so that the improvement is constant. The raising of dairy cattle is receiving the greatest attention. (Pl. I, fig. 2.) Two years ago the station erected the first dipping tank, and all cattle brought to it are dipped free of charge. The success gained from this work has induced planters in various sections of the island to build dipping tanks and periodically to dip all their cattle. The beneficial effects are very apparent. What is most needed now is a sufficient fund with which to inaugurate and conduct a definite campaign of attack to exterminate the tick which prevails throughout the island; then, by quarantine regulations, to keep it out. No money expended will yield a greater return to the people of Porto Rico than an amount sufficient to eradicate the cattle tick. This will eliminate the necessity of repeated dippings of cattle, and the adoption of proper quarantine regulations will keep the tick out of Porto Rico.

REFORESTING.

The larger portion of the lands of Porto Rico is not cultivated. These uncultivated lands, though not waste, produce very scanty pasturage. The station aims to find the crop or crops best adapted to every parcel of land in the island, so that all land may be made productive. Farmers are often greatly discouraged by the fact that they do not know what to plant on these lands so that a profit can be obtained from them.

On the mountain known as the Mesa, above Mayaguez, the station has 200 acres of land which has been cut over for many years and has become very sterile and gullied. Such lands should, as a first step, be planted to legumes to make them an agricultural success. The velvet bean and *Crotalaria* greatly improve these lands when planted in the first season. Experiments so far conducted by the station indicate that by a rotation with legumes these old lands can be made profitable. This land is typical of a large acreage of the island. On cut-over hillsides, the following trees have also given indication of success: Camphor, avocado, mahogany (Pl. I, fig. 2), and some lesser known native woods of economic value.

The eucalyptus is now found in all sections, small trees and seeds grown at the station having been distributed to all parts of the island. As a science and art, forestry is receiving increasing interest among the people. Many trees are being planted at the schools and around the homes in spite of the fact that no extended planting of trees, other than fruit trees, has been made.

FIBERS.

Among fiber crops sisal, henequen, jute, flax, and hat fiber are receiving the most attention. A machine for extracting fiber from the sisal was installed at the station during the year. A number of plantings have been made in various sections of the island, including one which covered over 500 acres. The weaving of baskets, hats, and mats is on the increase. The value of hats exported from the port of Mayaguez has amounted to over \$500,000 annually for several years. Most of these hats are made from the native straw and are not of the highest quality. The station has introduced and is extending the planting of the *Carludovica palmata*, from which the Panama hat is made. It aims to change in a few years the hat-weaving industry by the use of this kind of fiber to the exclusion of the native palm. A hat worth twice the value of one made from the native straw can be made with the same amount of labor. The process of growing and bleaching the straw of the *Carludovica* for hat weaving has been greatly fostered by the station. A campaign was made throughout the hat districts during the year to show methods of preparing and bleaching the straw.

The results obtained from the successful growing of flax during the last three years give promise of this becoming a new lucrative crop for the island. One of the largest firms producing flax has growing near Mayaguez 50 acres of flax for the production of seed, which will be sown in the States in the summer. The production of seed of such improved strains has led to the conclusion that Porto Rico may also be able to produce the fiber at a profit, as the climate lends itself to the retting of the flax.

PLANT BREEDING.

When a new plant is introduced at the station and has proved itself to be worthy of further trial specimens are disseminated as rapidly as possible throughout Porto Rico. Plant-breeding work is carried on by the station not only by selection but by crossbreeding. Probably no other line of endeavor has given such great results as this. Plants which a few years ago were entirely new to the island are now found in all sections. Planters appreciate this successful propagation and cooperate readily with the station whenever it has something new to recommend to them. Among the more valuable introductions receiving special attention during the year were the velvet bean, *Crotalaria juncea*, and Napier or elephant grass (*Pennisetum purpureum*). Some very important work has been done also in distributing throughout the plantations varieties of canes which are resistant to the mottling disease now threatening the cane industry.

While considerable work is being carried on in the island to determine the cause of the disease and to secure general data regarding it, the most logical way to combat the disease appears to be the growing of immune varieties. The station has two or three varieties that are very promising in this regard and has imported more for extended planting from the station in St. Croix, Virgin Islands.

CHEMICAL INVESTIGATIONS.

Studies on the effect of green manuring and the use of fertilizers on the yield of cane and on the conservation of nitrogen in the soil are under way, and different crops are showing some variation in composition as a result of the fertilizers applied. The tolerance of several classes of plants to acidity in the soil has been noted during the year. Investigations are being continued to determine the need of phosphates in the soils of Porto Rico, and the value of various forms of phosphates when applied as a fertilizer. These studies cover typical soils from various sections of the island, and are carried out in the plant house, where all the factors which enter into the growth of the plants can be controlled.

MINOR INDUSTRIES.

While the larger industries of Porto Rico are prospering, the steady increase in population necessitates the development of smaller agricultural products and manufactures. This station from its inception has sought to foster especially the interests of the small landholder and the farm laborer.

Among the small industries beekeeping, which was first exploited by the station 12 years ago, has grown enormously. During this fiscal year the exports of honey and wax amounted to \$682,380.

The station is constantly called upon to show beekeepers the necessity and advantage of upgrading their stock by the frequent use of purebred queens, and it is also cooperating with them in the matter of introducing more honey-producing plants.

EXTENSION WORK.

The extension work of the station continues to receive a great deal of attention. Members of the staff visited various plantations and held conferences with the planters. As direct results the correspondence has steadily increased from year to year, and clearly indicates the healthy, growing interest in the work of the station.

In order to keep in closer touch with some of the industries, especially fruit growing, which is conducted on the northern side of the island, the station maintains an office in the Federal Building at San

Juan. This office issues a series of publications known as Agricultural Extension Notes. These publications convey information gathered by different members of the staff from investigations and from observations made on their travels over the island. The results of agricultural research work in other tropical countries are also reviewed from time to time and brought to the attention of the planters. The Agricultural Extension Notes are issued in both English and Spanish and have a wide circulation. That these publications have materially increased the usefulness of the station is evidenced by the many inquiries and requests which are frequently received from planters in all sections of Porto Rico.

REPORT OF THE CHEMIST AND ASSISTANT CHEMIST.

By L. G. WILLIS and J. O. CARRERO.

AVAILABILITY OF PHOSPHATES.

Investigations to determine the relative availability of different phosphatic fertilizers and the phosphate requirements of the principal types of soil found in Porto Rico were carried to completion by the assistant chemist, and the results are now being prepared for publication.

The greater part of the past year was occupied in developing plans for continuing the work of the department. This necessitated a study of the agricultural resources and practices of Porto Rico, as well as of the results obtained in investigations at the station and by tropical investigators elsewhere. The chemist made several trips to different parts of the island to become familiar with soil types and crops, and to make such other observations as were necessary before any work of local value could be undertaken.

NITROGEN ECONOMY IN CANE SOILS.

As nitrogen is apparently the fertilizing element which is the limiting factor in cane production, plans were developed for a quantitative study of the nitrogen balance in soils on which cane is grown. Special attention is being given to leguminous green-manure crops to determine the extent to which they can supply the nitrogen required for cane culture. The major part of this investigation is being conducted on a series of 36 plats, each of which is planted to cane and so arranged as to furnish results under three systems of cropping. All plats are to be uniformly fertilized with liberal amounts of potash and phosphate, nitrogen being supplied in the form of nitrate of soda, sulphate of ammonia, and through the agency of a green-manure crop.

In addition to the 36 plats planted to cane, 12 smaller plats are being used, 6 of which will be kept bare, while the remainder will be allowed to grow the native vegetation, in order to compare the nitrogen content of soil so treated with that of soil of cropped plats.

It has been planned to supplement the results of the field experiments with data from pot experiments now being conducted, and work was started to determine the extent to which the accumulation of nitrogen by certain leguminous plants can be carried when drainage is eliminated and moisture is maintained at the optimum.

Obviously, these experiments must extend over a period of several years, since the analytical differences obtained in two or three consecutive years will be too small to be of any significance.

OTHER INVESTIGATIONS.

In addition to the study of nitrogen economy in cane soils, plans were made to investigate certain phases of plant nutrition, particularly the nature of the reactions of plants toward acid soils. The problem of soil acidity has been considerably clarified recently by the work of a number of investigators, and some of the latest hypotheses are significant, especially when applied to local conditions.

An attempt is also being made to supplement certain analyses which treat of the effect of fertilization on the composition of a crop, in order to learn whether an apparently uniform relation holds true invariably. A large amount of material is already available, but it is thought that a few additional determinations will suffice to indicate whether the problem is one deserving of further investigation.

MISCELLANEOUS ANALYTICAL WORK.

Continuing the policy of other years, analyses of miscellaneous samples of materials sent to the station were made whenever it was apparent that the information obtained therefrom would be of general agricultural value. A number of analyses were made to supplement the work previously done by other members of the station staff, the larger number of determinations being of sugars from variety plats of cane, and of vanillin developed in vanilla beans by different methods of curing.

An unproductive soil found near Dorado, representative of a considerable area, was studied to determine the cause of crop failures on the tract. An analysis of a typical sample indicated no lack of sufficient nitrogen, phosphate, or potash, but showed the content of lime and magnesia to be unusually low and the lime requirement very high. When rice was used as a test crop in a pot experi-

ment of limited scope, it was found that liming or leaching decreased the amount of growth, but that a notable increase above the yield on the untreated soil was produced when treated with lime, phosphate, and potash. It is thought that where there was an absence of sufficient lime in the soil the phosphate, added to fertilize the field crop, had been rendered unavailable by reaction with iron, and that the rational plan for improvement is to heavily lime the soil, and thereafter to apply phosphate and potash in liberal amounts. This treatment has been recommended for a series of test plats in the field. The possibility that toxic aluminum compounds might have been partly responsible for the poor crop was considered, but, since it apparently was not the major cause of the trouble, no attempt was made to settle that phase of the problem.

REPORT OF THE HORTICULTURIST.

By T. B. McCLELLAND.

MANGOES.

In the last two seasons 14 seedling trees from grafted Cambodiana mangoes fruited. Of these, 7 came true to the parent type. The others differed in several of the characteristics, including color, shape, size, texture, sweetness, flavor, fiber, quality, shape, and veining of the seed. In the accompanying illustration (Pl. II, fig. 1) the parent type is shown in the center with variant forms of seedlings on either side. The one at the right was a large fruit which weighed from three-quarters to more than a pound, and was sweet and agreeable in flavor. Its only objectionable characteristic was the considerable amount of fiber, which was found principally along the ventral margin. The mango at the left differed greatly both from that just described and from the parent. It was a small fruit, ranging from a quarter to a half pound in weight; moreover, it was proportionately short, had a broad base and rounded apex, and its dorsal edge formed a nearly perfect semicircle. Though sweet and pleasing in flavor, its very abundant fiber causes this fruit to be placed among those of poor quality. Another marked difference was shown in the veining of the seed, which was raised rather than sunken like the typical Cambodiana. Seed of this variety should be planted, the trees which fruited in the last two seasons having given indications that Cambodiana seedlings equal in quality to the parent can be secured. Among those which differ from the parent type are found some variations which prove objectionable; other variations may not be so considered.



FIG. 1.—VARIATION IN SEEDLINGS OF CAMBODIANA MANGOES. TYPICAL FRUIT IN CENTER.

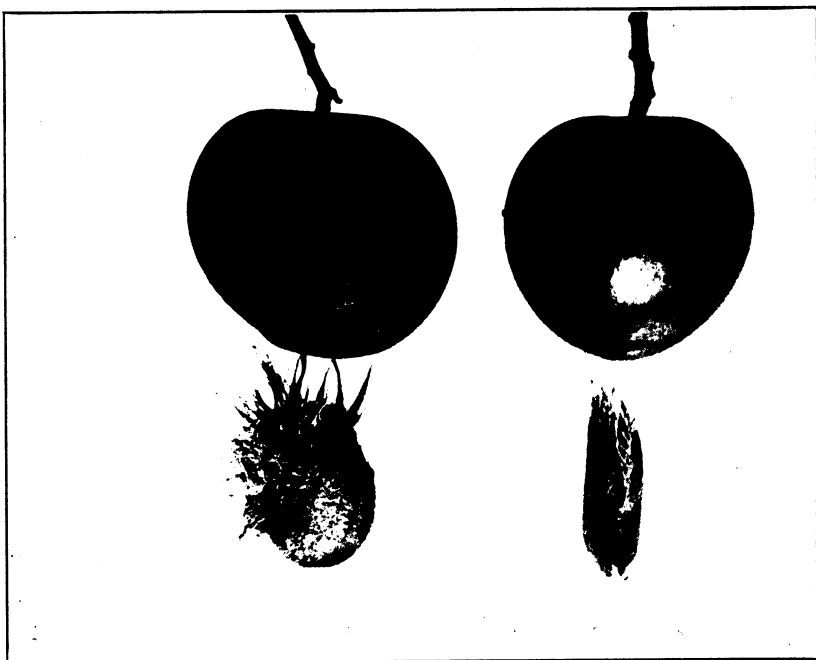


FIG. 2.—BRINDABANI MANGO (S. P. I. No. 10637).

Itamarca continues to show itself a very prolific producer of late fruit. For this reason it is especially valuable for lengthening the season, since its crop is matured after most of the other varieties are through fruiting.

Several varieties this season are fruiting for the first time, including Brindabani (S. P. I. No. 10637) and Fernandez (S. P. I. No. 19117), which, in September, 1910, were received as small inarched plants. The latter variety will mature its crop too late for the present report.

Brindabani produced a crop of about 225 fruits (Pl. II, fig. 2). These were borne in singles or in clusters of from two to eight. The form is almost spherical. Five fruits, which averaged 179 grams in weight, averaged in length, $2\frac{3}{8}$ inches; in breadth, $2\frac{1}{8}$ inches; and in thickness, $2\frac{3}{8}$ inches. The stem, which is inserted squarely in the fruit, is about three-eighths inch long by three-sixteenths inch in diameter. The base of the Brindabani is flattened; the ventral shoulder is slightly the more prominent, and the cavity is broad, shallow, and slightly undulating. The apex is obtuse, the stalk inconspicuous, slightly depressed, and about an inch distant from the longitudinal apex. The surface is smooth, the color greenish yellow with a red blush, and the dots, which are moderately abundant, are small and straw colored. The skin is very thin, and in the ease with which it separates from the flesh, surpasses all varieties previously examined. In a fruit which weighed 202 grams, the skin weighed but 17 grams. The flesh is orange in color and very juicy. The fibers, which are green, are long and abundant near the base and near the ventral margin of the seed, along which they are connate at their base. The aroma of the uncut fruit is somewhat applelike. The flavor near the skin is pleasing and is reminiscent of that of the Concord grape. However, the acidity near the seed is too pronounced to be agreeable. The quality can not be considered more than fair. The seed is plump, obovate in outline, has a sharp, prominent beak and a slightly raised veining. In a fruit which weighed 157 grams, the seed weighed 19 grams and measured $1\frac{1}{8}$ inches in length, $1\frac{1}{8}$ inches in breadth, and three-fourth inch in thickness. It is monoembryonic. The crop matured throughout June and the first half of July. The fruit of this variety is very susceptible to disease, since very few fruits ripened in good condition and the major part were diseased, apparently with anthracnose. The foliage is less ornamental than that of many other varieties, the leaves being narrow and the branches delicate. The leaves are linear-lanceolate, some measuring as much as 9 by $1\frac{1}{4}$ inches. Others are only half as long and a little more than half as broad.

Ground cork, in which grapes are imported in the holds of vessels from Europe, was tested as a packing for mangoes. Fruits, which

were picked in the morning, were left indoors on shelves until 4 p. m., when they were packed unwrapped in a box filled with ground cork. In from 20 to 36 hours after they were packed in a room where the temperature ranged between 30.5° and 28° C., respectively, the thermometer within the box registered 36° C., and the temperature rose to 37° C. within 2½ hours after the latter inspection. Under these conditions the ripening of the fruit was very rapid, and in a few crates so shipped to the States, approximately two-thirds of the fruits were found rotten on their receipt, 10 days after picking. Another, but well-ventilated crate, in which the fruits were wrapped in orange paper and packed with excelsior, and for which refrigeration was requested on the boat, showed a decay of only 8 per cent 10 days after shipment.

VANILLA.

Two publications were issued within the year on the work with vanilla. One² suggests a partial explanation for the very marked ectogony which was observed to follow the crossing of certain species. The other³ is practically a report of the progress of work which is being continued. Crop limitation as reported here showed its effect on the weight and size of the beans of a single crop. Now the effect is being shown on the capability of the vine for further production. The average yield in number of pods per vine for the 1917 crop was rated at 100 per cent for each group; that of the 1918 crop amounted to 114 per cent for the group in which the production was limited to 2 pods per cluster; 98 per cent for the group in which 4 pods developed per cluster, and but 76 per cent for the group in which 6 pods were borne per cluster. Each group showed an increase in weight of average production per vine and also an increase in size of average bean. These data show that where but two pods developed per cluster the vine made sufficient new growth for the production of a greater number of pods the following season. Neither of the other groups did this. The same relative sequence of groups as for the preceding crop was maintained in regard to the weight of the average production per vine and of the average pod.

It is considered desirable to learn as definitely as possible the appearance of the pod just prior to its splitting. Some pods become quite oily, while others do not. A number of pods which were labeled as soon as oiliness was observed were left on the vine until they began to split and were examined at frequent intervals. The interval between the time of labeling and the time at which the pod was last observed unsplit ranged from 4 to 55 days and averaged 27 days. The oiliness extended from about one-third of the pod's

² U. S. Dept. Agr., Jour. Agr. Research, 16 (1919), No. 9, pp. 245-252,

³ Porto Rico Sta. Bul. 26 (1919), p. 32.

length to nearly the whole. As maturity is approached the pod assumes a mellow appearance, as though the oil had soaked in.

That a short delay between the time of picking and curing may cause a large depreciation in the value of pods was indicated by a number which, after being picked, were placed on a table within doors. The following day the split pods were sorted out. Two days later nearly one-fifth of the remaining pods had split and more than one-half split within a week after they were picked. The reduction in weight of pods of different lengths on drying was found very uniform.

Considerable attention was given to investigating different methods of curing, an electric oven being used for most of the work. The varying factors studied included temperature, humidity, and duration of heating. Very striking differences were noted in the appearance of the cured beans and in the development of vanillin crystals, the results showing variations from lots in which no crystals whatever developed to others in which the beans were white and glistening under their profusion of crystals. Inasmuch as this investigation is to be continued in order that the results already obtained may be confirmed and amplified, it is hoped that a highly satisfactory method of curing vanilla by the employment of an oven can be worked out.

The root development of cuttings which were not in connection with soil or leaf mold has been reported⁴ as observed up to 24 weeks after the cuttings were tied to upright slats. One year from the time of placing nine cuttings were still making active root growth in their endeavor to reach the ground. The roots developed by some equaled in length the cutting itself, two exceeded 4 feet, and but one cutting failed to develop roots. The nine cuttings which were not making active root growth were then removed from the supports and placed on the ground, the lower portion of each cutting being covered with damp leaves. By the end of the fifth week all had started new root growth.

Numerous vanilla cuttings have been supplied to interested people, and several private plantings which are being started on a commercial scale are doing well.

A comparative test with different chemical and organic fertilizers for vanilla vines was begun.

COFFEE AND CACAO.

Fertilizer, variety, and pruning tests with coffee are being continued. A number of coffees which were not tested here previously, or else tested on a very small scale, are now coming into bearing.

⁴ Porto Rico Sta. Bul. 26 (1919), p. 13.

At a little more than four years after date of planting the seed of Robusta coffee, which is now so largely grown in Java, it was found that a fraction over 60 per cent of the most favorably located trees were in production. This crop averaged nearly 2 liters of cherry coffee per fruiting tree. The production prior to this was almost nil.

Various leguminous trees, which hitherto have not been used, are now being tested as shade trees for coffee plantations in Porto Rico. One of these, *Gliricidia maculata*, is proving to be so satisfactory that the station has distributed some of it to coffee growers. It may be propagated by either seed or cuttings. As the leaves are small and the trees dwarf, the shade can be easily regulated by close planting at first, and, later, by eliminating superfluous trees. Plate III, figure 1, shows a young planting of Bourbon coffee shaded by this legume at less than three years from the time of placing the cuttings between each two coffee trees.

Individual records on the yields of cacao trees are being continued. In the youngest planting a little less than half of the trees fruited at five years from seed, and averaged a little less than six pods per tree. The production prior to this had been very small.

VEGETABLES.

The testing of the comparative earliness, productiveness, and suitability to local conditions of various garden and field beans was continued and enlarged by the addition of a number of varieties from the west coast of the United States. Two plantings, each containing more than 50 rows, were made. The December planting suffered from insect attacks, and, as a consequence, satisfactory data as to crop could not be obtained. The yields of the late February planting were diminished by drought. Otherwise they served well for comparison of varieties, and data were recorded for the individual plants. Lady Washington and Navy, which were not tested the preceding season, ranked with, or surpassed, some varieties grown locally. They did not, however, equal in yield the Porto Rican white bean, which was exceeded only by the black Venezuelan bean. Among the plants of the latter, which is of very late maturing habit, an early maturing strain has been found and is being propagated for testing.

A study in inheritance of color and in the yield of several strains of locally grown and imported pigeon peas is in progress.

Varieties of locally grown and imported Lima beans were planted, some of which, when analyzed by the Food and Drug Inspection Laboratory of the Bureau of Chemistry, United States Department of Agriculture, were shown to be rankly poisonous.

Several varieties of tomatoes were tested and Mack's Prolific (F. H. B. 23572) proved of excellent quality.



FIG. 1.—GLIRICIDIA MACULATA AS COFFEE SHADE. TREES
LESS THAN 3 YEARS FROM CUTTINGS.



FIG. 2.—PROPAGATING HOUSE OF PORTO RICO STATION.

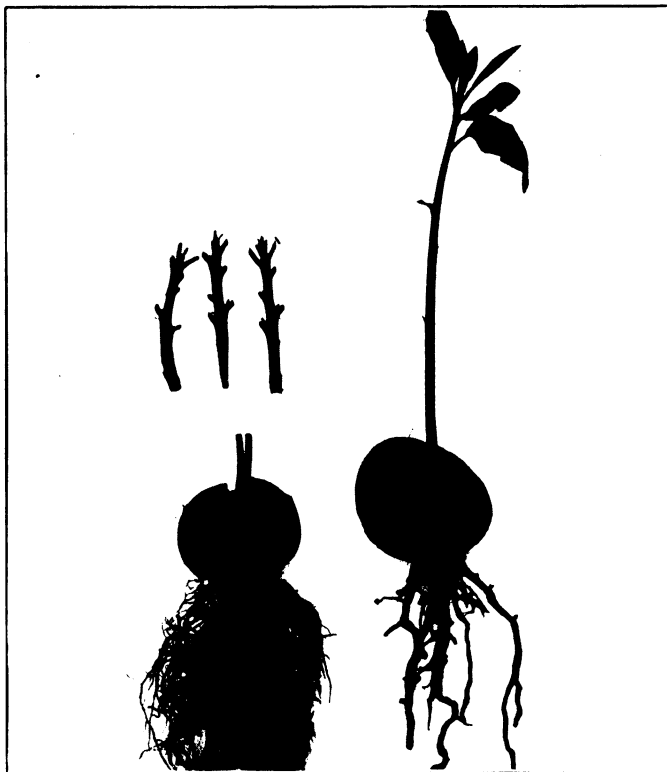


FIG. 1.—STAGE OF SEEDLING USED AND PREPARATION FOR GRAFTING.

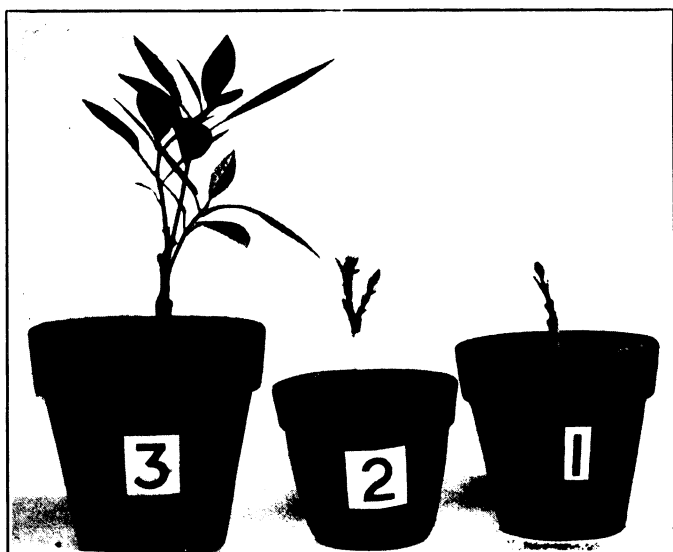


FIG. 2.—GRAFTED AVOCADO SEEDLINGS GROWING IN POTS.

Yams of the more valuable introduced varieties were distributed in 75 municipalities of the island.

MISCELLANEOUS.

A fertilizer test has been running 4 years with young coconut palms which are just beginning to blossom. Records of production, which will show more clearly the period over which the fertilization was effective, are being continued on the older grove previously referred to,⁵ and which has not received any fertilizer for some years.

A planting has been made of Guatemalan avocados. The station has been very successful in propagating avocados by grafting the desired variety on young seedlings as shown in Plate IV.

Attention is being given to the introduction, propagation, and distribution of various plants of economic or ornamental value.

A plant of *Thunbergia erecta* var. *cærulea* has developed a sporting branch in whose flowers the rich purple of this variety is replaced by lavender. As no printed mention of varieties other than *cærulea* and *alba* has been found, and as these are the only two which have been so far observed locally, it is thought that this new variety, which may be termed *lilacina*, is deserving of distribution. Several plants of this sport have already been propagated and distributions will be made later.

The propagating house shown in Plate III, figure 2, has proved well adapted to use in the Tropics. It consists of a tile roof borne on reinforced concrete pillars, and is open on all sides.

REPORT OF THE ENTOMOLOGIST.

By W. V. Tower.

MOTTLING DISEASE OF SUGAR CANE.

A number of experiments have been carried on with various cane insects to determine whether they transmit the so-called mottling disease of sugar cane. For these experiments, seed cane was obtained from a district comparatively free from the disease. This selected seed was planted in pots, which were immediately covered with cloth cages so that insects were unable to come in contact with the canes, and the plants were watered through the cloth. After the canes germinated and the young sprouts were 3 to 5 inches long, various cane insects from infected plants were introduced in the cages.

Immature mealy bugs (*Pseudococcus sacchari*) were introduced and became established in a number of pots. In other cases the mealy

⁵ Porto Rico Sta. Rpt. 1917, p. 21.

bugs were crushed and rubbed on the developing buds and shoots. Punctures were also made in the buds and shoots and the crushed mealy bugs were forced into the young canes, but in no instance did the cane develop the mottling disease.

A number of species of leaf hoppers found on infected cane were put into the cages in various stages of development and allowed to establish themselves until a second generation appeared. The cane, however, did not become infected with the disease.

A few sugar-cane moth borers (*Diatraea saccharalis*) were transferred from sickly to healthy plants by placing the borer under absorbent cotton. No infection appeared as a result.

A number of leaf-eating insects were fed in these cages, yet none of the cane developed the disease.

HONEY PLANTS.

A daily record of the blossoming periods of the most important honey plants and trees is being kept. This will give data concerning the period of bloom of the various plants. The length of bloom and dates of blossoming being governed by the rainfall, on account of the climatic differences, the period of bloom will have to be determined for each district. During the fiscal year ending June 30, 1919, 3,817,031 pounds of honey, valued at \$666,457, was exported from the island.

OBSERVATIONS ON CITRUS SCAB.

Scab still continues to be the worst pest to the citrus grower.

An excessive amount of nitrogen in the soil seems to have a marked tendency to produce scab in young groves. Trees that are growing fast and have rank, luxuriant growth are more susceptible to scab than those which are making more moderate growth. It is thought that trees which have produced excessive amounts of scabby fruit during their early growth will, when they slow down, produce clean, handsome fruit, and that old trees which have been given an extra application of fertilizer running high in nitrogen will produce coarse and scabby fruit. This point will have to be determined by fertilizer experiments. Furthermore, it is not believed to be advisable to make heavy applications of quick-acting fertilizers just previous to the blooming period of the tree. This will have to be governed by the nature of the previous crop and the present condition of the tree. For instance, if the grove, taken as a whole, has not produced a heavy crop during the year and the trees have developed one or two strong growths, it would be better not to make too heavy an application of quick-acting fertilizer containing a high percentage of nitrogen. On the other hand, if the grove has borne an extra heavy crop, an

excess of nitrogenous fertilizer would probably be of great benefit to the trees and perhaps would not be conducive to scab. Therefore it seems more advisable to build up the tree during the year and to allow it to develop its normal bloom in the spring rather than to try to force an early bloom by the use of heavy applications of nitrogenous fertilizers.

It has frequently been noticed on inspection trips that reasonably old groves, which in previous years were considered free, were literally covered with scab. Upon inquiry, it was found that during the past season these groves had been plowed, and that heavy applications of nitrogen had been given, although plowing had not been practiced previously. This heavy early spring plowing cut off many of the large roots, and from those which remained thousands of small feeding roots started. These reached out into the newly plowed soil containing the highly nitrogenous fertilizer. The excessive resultant tree growth often is very succulent and susceptible to fungus diseases. Such conditions are modified where it is the practice to plow every year and to force down the feeding roots so that heavy flushes will be infrequent.

Various types of soil have marked influence on the presence or absence of scab. Very fertile soils which contain excessive amounts of humus produce trees more susceptible to scab than those which are grown on sandy soils poor in fertility and where the nutriment has been supplied in commercial fertilizers. Excessive amounts of high nitrogenous fertilizers on these sandy soils fail to produce the rank growth found on the first-mentioned type of soil.

In one of the plantations on the north side of the island some of the groves are located in pockets among the hills. The trees have always been well fertilized and thoroughly cultivated. Their leaves are very large and the foliage is heavy and rank. The crops have always been light and very scabby, due apparently to the fact that all their vitality has been used in developing large, strong trees. Since the trees were large enough to carry a four or five box crop, it was decided to cut down the supply of nitrogen in some of the pockets and to use just the usual amount of phosphoric acid and potash. These plans were carried out, with the result that there is now a very heavy crop freer from scab. The trees seem to be settling down, and the fruit is not developing in clusters, nor are the leaves large and succulent.

Neglected or worn-out groves do not generally have scabby fruit. The opening of trees by pruning may also help them to resist scab. The weather conditions have an important bearing on the amount of scab. Bloom that comes during a period of dry weather is generally free from scab, while fruit which appears during the rainy period is almost sure to be infected.

WORK AMONG THE CITRUS GROWERS.

In furthering the citrus work of the station, practically all the larger groves on the island were visited during the year.

The following are lines of work in progress:

(1) The supplying of humus to old closed-in groves. A number of growers are testing plats with mulch, using cane trash and swale grass for the purpose, while others are raising velvet beans, which will be carried on to the ground, where they will act as a mulch and supply humus.

(2) The planting of leguminous trees as permanent windbreaks to take the place of the bamboo which was generally used in the early days. Some planters are using improved mango trees as permanent windbreaks.

(3) Cover crops to supply nitrogen and humus in young groves which have not closed in.

(4) Endeavoring to interest growers in the benefits to be derived from keeping individual tree records and in the importance of selecting budwood from trees whose records have been kept for a number of years. A few growers have been keeping tree records for budwood, but very few have been keeping individual tree records.

(5) Study of various methods of cultivation to note their effect on early bloom. Some groves which were in clean culture with a dust mulch blossomed, while others that were not worked and put in good condition did not bloom. Groves that were not plowed and covered with a dust mulch blossomed, but they did not hold their fruit.

It has been observed that fertilizer applied in December and January has a tendency to bring on early bloom and puts the trees in condition to hold the young fruit.

A small nursery of 1,000 trees has been planted at the station. These will be budded to the best varieties for distribution. Part of this stock will be used for tree-selection work.

Notes regarding growth and number of fruits per tree have been taken on the citrus stock experiment at the station. Budwood from standard varieties is being sent out from time to time.

CITRUS THRIPS.

Reports on serious injury by thrips to oranges have been noted in California, Arizona, and Florida, and as these insects have been found in the citrus blossoms in Porto Rico, it was thought advisable to make a survey of the station groves to determine the thrips invasion. A survey on grapefruit was undertaken during its spring blossoming period. A daily record was kept of many trees on which a number of thrips were present. Counts were made each day for the

full period of the bloom in the three stages of flowering—fully open, just open, and partly open. It was found that there was present an excessive number of thrips. Some blossoms, containing over 25 thrips, were tagged. The average number of thrips for grapefruit bloom was 27. It was found that the averages for the fully open, just open, and partly open blossoms were practically the same. The greatest amount of infestation occurred just before the period of white bloom. The infestation during the heaviest bloom was very constant, but from this time on it decreased. At present practically no damage seems to have resulted, and all the grapefruit trees have borne a heavy crop.

Since these experiments on grapefruit were made, thrips marks have been found on oranges in some of the cultivated groves on the north coast, and also on wild oranges in the local packing houses at Mayaguez.

REPORT OF THE ASSISTANT IN PLANT BREEDING.

By W. P. SNYDER.

The work in plant breeding was resumed on December 30, 1918, when the writer returned from a leave of 11 months for military service. Some of the lines of work begun the preceding year were resumed and several new projects were taken up.

VEGETABLES.

A planting of vegetables was made in the spring in order that seed might be obtained from them. The summer rains almost destroyed the root crops, but a planting of celery, which is still in fair shape, may produce seed in the coming winter.

Six rows of tomatoes were set out on May 11, including Greater Baltimore, Matchless, and a small native variety. The average production per plant was 1.45 pounds for the native, 1.06 pounds for Greater Baltimore, and 0.88 pound for Matchless. The average size of fruit was 1.8 ounces for the native tomato, 4.9 ounces for Greater Baltimore, and 4.3 ounces for Matchless. The poor results are due to the ravages of the *Cladosporium* fungus during wet weather. The native tomatoes are much less susceptible to this fungus than are introduced varieties. A cross has been made between the Greater Baltimore and native tomato, it being the hope that a large fruited tomato having the vigor of the native variety may be obtained.

In case of melons also, varieties from the States do very poorly, owing to their susceptibility to disease and their lack of adaptability

to Porto Rican conditions. Crosses have been made between introduced kinds and a large, very vigorous native muskmelon. A trial of from 4 to 8 hills each of several melon varieties, with 4 vines to the hill, gave the following results:

Results of a trial of several melon varieties.

Variety.	Number of fruits per hill.	Weight of fruits per hill.	Average weight of fruits.
		<i>Pounds.</i>	<i>Pounds.</i>
Native muskmelon.....	3.93	19.63	5.00
Berry muskmelon.....	4.50	4.53	1.01
Salmon Tint Pollock muskmelon.....	2.67	2.68	1.01
Flat Jenny Lind muskmelon.....	3.86	2.46	.64
Golden Hybrid cassaba.....	1.7	2.73	1.61
Winter Pineapple cassaba.....	2.0	2.42	1.21
Honey Dew cassaba.....	1.6	2.03	1.27
Hybrid cassaba.....	1.0	.86	.86
Fordhook Early watermelon.....	4.0	15.16	3.80
Baby Delight watermelon.....	2.5	6.94	2.77

A trial of a cross between the native white field corn and Early Adams sweet corn, obtained from P. G. Snyder, of Aibonito, gave an average of three ears, with a total weight of 13 ounces per hill of two stalks. The yield of this cross is very much poorer than that of native corn, though better than sweet corn varieties from the States. A trial of Oregon Evergreen sweet corn proved a complete failure. A fresh importation of white Cariaco corn from Venezuela has been made. This is the most satisfactory corn for table use that has been tried at the station.

A planting of Porto Rican grown potatoes was made to test the practicability of potato growing in the lowlands. Seed was also obtained from the Office of Foreign Seed and Plant Introduction, Bureau of Plant Industry, United States Department of Agriculture, of the Portuguese Red (S. P. I. 45023), a potato from Hawaii, supposed to be resistant to late blight and wilt.

GRAPEFRUIT.

Two kinds of work have been undertaken with grapefruit—bud selection and crossing. Tree records were kept for the past season on a grove near Pueblo Viejo. The trees in this grove are practically all of the Duncan variety, and range in age from 5 to 14 years. Trees of the same age are planted in the same block. Records were kept of the number of boxes of fruit per tree, approximate size of fruit, smoothness of fruit, and growing habit of tree. By use of these records the most valuable trees in the orchard may be found, and budwood can then be selected from them in order that desirable strains may be propagated. The notes on growing habit of trees were kept in order to determine whether there is a relation between

the habit of a tree of the Duncan variety and its value for fruit production. By the selection of budwood from the best trees, it is planned to obtain desirable strains which have a high, uniform yield, and small sized, smooth, high-quality fruit, borne in small clusters. In order that reliable data may be obtained, tree records should be kept over a period of several years. Nevertheless, in order that the work might be well started, five of the most promising trees were selected, the selections being based on the records for the preceding crop and the set of fruit for the new crop. Bearing budwood from these trees was budded into grapefruit stock in the station nursery. The value of this kind of work to the fruit grower has been demonstrated, and it is now known that the keeping of tree records, the subsequent elimination of drone trees, and the selection of budwood from the best trees, constitute a most important and profitable part of the orchardist's work.

During the spring bloom of 1919, about 100 reciprocal crosses were made between the Duncan and Triumph varieties. The seedlings from these crosses will be budded into bearing trees at an early age to hasten their fruiting. The Duncan and Triumph are two common commercial varieties in Porto Rico. The Duncan is commonly considered of higher quality and comes into bearing late in the season, being marketed usually from October to April or May. The Triumph, though not so desirable a fruit as the Duncan, is ready for market earlier and is quite resistant to the citrus scab, the most troublesome disease of citrus fruits in Porto Rico. Hybridization of these two varieties should be a very promising line of work.

BANANAS.

The Chamaluco banana, one of the important food plants of Porto Rico, is very susceptible to the banana wilt, or Panama disease. The description of this disease and of experiments carried on for its control have appeared in former reports of this station.⁶ The methods tried for the control of this disease have offered little hope of success, with the possible exception of the development of a resistant strain. Work in this line was begun by the selection of the most healthy plants from a large, thoroughly diseased plat of bananas which were planted together in one part of the diseased plat. These selected plants, on reaching maturity, were much more vigorous and healthy than the adjacent plat of nonselected plants, despite the fact that a number of the selected plants had developed the disease. The entire banana plat was gone over, including selected and nonselected plants, and a new selection was then made of plants which showed no trace of disease. These, with their suckers, were planted in a section 70 by

⁶ Porto Rico Sta. Rpts. 1915, pp. 34-41; 1916, pp. 29-31.

150 feet of the diseased plat after the old diseased plants had been dug out, chopped into small pieces, and thoroughly worked into the soil, so that infected material was well distributed throughout. After a period covering three months of growth 39 plants, or 36.1 per cent of the planting, began to show the presence of the disease by the characteristic yellow color and gradual wilting of the leaves. Signs of disease shown at such an early stage are very unusual. Quite a number of the selected plants, however, are now vigorous and healthy, and some of them may prove to be really resistant.

SUGAR CANE.

The work with sugar cane has consisted in the production of seedling canes and of variety testing. A planting of cane, made in September, 1917, was used for the variety tests and as the source of arrows for planting. The planting was made primarily for the purpose of obtaining arrows, the varieties being arranged largely in single rows. The intention was to obtain arrows of the Otaheite variety, fertilized with pollen from pollen-fertile varieties, but inasmuch as the Otaheite proved practically a complete failure, due to the attacks of the mottling disease, this plan was abandoned. A few arrows of Otaheite were obtained from other localities.

The arrows were sown in seed boxes and covered with a thin layer of coconut fiber. Apparently, however, the coconut fiber hindered germination. This plan, therefore, is considered inferior to that whereby the arrows are covered with a very fine sifting of sand, and water is applied at frequent intervals. The use of manure water produced a slight increase of growth in the young seedlings over the use of ordinary water, the effect being most marked during the period before the first transplanting, which was from six to eight weeks.

The following table shows the varieties from which arrows were obtained, their relative abundance of arrow production, and the approximate relative germination of arrows from the different varieties:

Relative production and approximate germination of arrows from different varieties of sugar cane.

Variety.	Production of arrows.	Approximate germination.	Variety.	Production of arrows.	Approximate germination.
P. R. 260.....	Prolific.....	Fair.	P. R. 210.....	Medium.....	Excellent.
G. C. 1486.....	do.....	Very poor.	P. R. 292.....	do.....	Poor.
G. C. 1480.....	do.....	Poor.	D. 109.....	do.....	Excellent.
G. C. 1070.....	do.....	Very poor.	B. 3922.....	Scant.....	None.
M. P. R. 3.....	do.....	Do.	P. R. 318.....	do.....	Poor.
Kavangiro.....	do.....	Do.	G. C. 1454.....	do.....	Fair.
Java 36.....	do.....	Do.	Java 234.....	do.....	Very poor.
B. 117.....	do.....	Do.	Java 228.....	do.....	None.
P. R. 317.....	do.....	Fair.	G. C. 701.....	do.....	Very poor.
M. P. R. 4.....	Medium.....	None.	Otaheite.....	do.....	Do.

The seedlings, after being twice transplanted, were finally set in the field in June. About 800 seedlings are on hand at present, all of which show traces of the mottling disease, some very slightly.

The cane used in the variety test was harvested 16 months after it had been planted. Just before it was harvested notes were taken on varietal characters and on the prevalence of the mottling disease. Since the varieties were arranged in single rows, with the exception of the M. P. R. seedlings, only a rough comparison could be obtained, yet in many cases the difference in yield was great enough to be very significant. Tests for sucrose were made by the chemical department. The results of the variety test follow:

Results of tests with varieties of sugar cane, showing relative difference in yield and prevalence of mottling disease.

Variety.	Average yield per hole.	Calculated yield per acre. ¹	Sucrose content.	Mottling disease.	
				Occurrence.	Damage. ²
	Pounds.	Tons.	Per cent.		
Kavangire.....	95.9	83.56	12.2	Not noticeable.....	None.
B. 1753.....	75.0		16.1	Abundant.....	Small.
G. C. 1480.....	60.0	52.27	17.2	Moderate to abundant.	Slight.
Java 36.....	59.8	42.13	17.25	Abundant.....	Do.
M. P. R. 3.....	55.7	48.56	15.3	do.....	Large.
B. 3412.....	44.4		15.3	Moderate to abundant.	Bad in spots; otherwise slight.
B. 6450.....	44.1	38.38	17.1	Small.....	Apparently small; cane badly lodged.
P. R. 292.....	42.9		14.7	Abundant.....	Moderate.
M. P. R. 4.....	40.3	40.44	14.9	do.....	Serious.
B. 4596.....	40.0		12.0	Moderate to abundant.	Do.
G. C. 1070.....	39.3	34.23	16.1	Very slight.....	
G. C. 1486.....	38.2	33.27	15.3	Slight.....	Slight.
G. C. 1479.....	36.4	31.71	13.8	Abundant.....	Large.
P. R. 317.....	53.8	31.25	13.7	Moderate to abundant.	Small.
G. C. 1332.....	34.7	30.22	17.2	do.....	Do.
B. 3922.....	33.5	29.15	17.0	Abundant.....	Slight to moderate.
G. C. 1451.....	33.1	28.86	15.4	Slight to moderate.....	Large.
Java 234.....	31.3	27.30	16.0	Abundant.....	Very serious.
D. 117.....	35.5	27.03	15.5	do.....	Serious.
G. C. 493.....	30.7	26.72	14.3	Fairly abundant.....	Do.
G. C. 701.....	27.3	23.74	16.5	Moderately abundant.	Do.
G. C. 1346.....	26.3	22.94	13.6	Abundant.....	Large.
D. 109.....	51.9	22.59	16.8	Moderately abundant.	Do.
G. C. 1419.....	30.8	22.32	15.4	Abundant.....	Do.
Java 228.....	25.5	22.16	16.8	do.....	Serious.
P. R. 260.....	47.1	21.90	14.0	Slight, if any.....	Not noticeable.
M. P. R. 2.....	22.6	19.71	15.1	Abundant.....	Large.
M. P. R. 1.....	20.8	18.08		do.....	Do.
P. R. 318.....	32.3	16.41	15.0	do.....	Do.
B. 109.....	28.0	15.25	16.2	do.....	Serious.
P. R. 210.....		15.06	15.4	do.....	Moderate to large.
P. R. 208.....	18.9	8.25	14.7	do.....	Large.
B. 347.....	16.8		15.0	do.....	Very large.
P. R. 270.....			15.9	do.....	Serious.
P. R. 376.....	(*)	(*)	17.0	Complete.....	Large.
B. 208.....	(*)				
M. P. R. 5.....	(*)				
M. P. R. 6.....	(*)		14.3		
Otaheite.....	(*)				
Seely seedling.....	(*)		17.7	Abundant.....	Very large.

¹ Terms indicating the amount of damage by disease are used in the following order of increasing damage: Slight, small, moderate, serious, large, very large.

² In a few cases where the row length could not be determined, the yield per acre was not calculated.

³ Outside rows.

⁴ Harvested together by mistake.

⁵ Failure.

By far the heaviest yielding cane is the Kavangire, a Japanese cane, which, in addition to producing immense stools of very slender canes, is resistant to the mottling disease. However, its juice is low in sucrose, and it is very difficult to harvest on account of its slender canes. For these reasons the Kavangire is not likely to find much favor as a commercial cane, but should be very valuable for use in breeding new varieties. The past season's trials indicate that it is practically self-sterile, and, consequently, adapted to cross-pollination with pollen-fertile varieties. Other promising varieties include B. 1753, G. C. 1480, G. C. 1486, and Java 36. The variety P. R. 260, which has been quite free from mottling disease, did not give a large yield. Notes were made of the extent of mottling disease on the ratoon growth seven months after the first crop was cut. The Kavangire and Java 36 are showing strong resistance. The varieties G. C. 1480, G. C. 1486, G. C. 1070, and G. C. 1454, are standing up moderately well, and a fair amount of resistance⁷ is shown by M. P. R. 3, B. 3922, and Java 228.

BEANS.

The work in bean selection was continued, and from a planting made in February, 1919, yields were obtained for 25 selections of the black Venezuelan bean and 5 other nonselected varieties. The average yield of all black Venezuelan selections was 2,131.3 grams of beans per 70-foot row; the average yield of Santo Domingo brown was 1,129.1 grams per row, and of Porto Rican red 1,010.4 grams per row. The yields of White tepary, New Mexico pinto, and Mexican red were very poor. Additional plantings of black Venezuelan selections were made in March and in June.

Crosses were made between black Venezuelan and Mexican red and between the Porto Rican red and White tepary varieties, and first generation plants were grown. Owing to the ravages of the bean blight, these plants were almost destroyed, despite the fact they were frequently sprayed. A few seeds were obtained, however, and these were turned over to the horticultural department for planting.

CORN.

Thirty-six ears of corn of different types, which were obtained from several different localities through the agricultural extension department, were planted separately in late April and early May. These were harvested in August, and their best yielding rows were selected as a basis for future selection. The yields of rows with

⁷ The word "resistance" is here applied to varieties on which the disease may be prevalent, but which are not seriously injured thereby, as well as to those varieties which show only a slight amount of disease.

good stands ranged from 8 to 42 pounds per 100-foot row without the application of fertilizers, an equivalent of 14 to 72.6 bushels per acre.

An experiment has been begun for the purpose of studying the correlations existing between certain characters of plant and ear, the yield of grain, size of ear, and the length of season. The progenies of 10 ears have been selected for this work. They will be planted in 20 lots, each of which will be subjected to continued selection through a series of years for 2 characters of plant or ear, and the desired correlations will be determined for each generation. Each year the same characters are to be studied by securing the measurements of several hundred individual plants from a uniform lot of seed, and by correlating plant and ear measurements with the yield of grain from the same plants. During the present season, the work was begun by taking data on corn plants from unselected seed. Measurements were also made on the parent ears used for the ear-to-row tests mentioned above, and on plant characters of the progenies of 30 ears, from which correlations with yield of grain, size of ear, and length of season will be determined.

REPORT OF THE SPECIALIST IN FARM MANAGEMENT.

By H. C. HENRICKSEN.

The last annual report of the specialist in farm management dealt exclusively with emergency work in cooperation with other agencies. That work at the beginning of the fiscal year was left in charge of an assistant, although the writer kept in close touch with it until February, when it was discontinued. In addition to the propaganda for food production, several lines of investigation were conducted through the 40 field agents employed. As some of this work was interrupted by the discontinuance of the organization, a final report can not be submitted at this time.

TIME OF PLANTING AND DISTRIBUTION OF ACREAGE OF SOME FOOD CROPS.

Questions dealing with time of planting and distribution of acreage of food crops were answered through the crop estimates received each month from September, 1917, to January, 1919, inclusive. The reports from the 12 months, November, 1917, to October, 1918, are probably the most reliable, and from them the following data have been tabulated:

Corn (80,000 acres planted).—Planting by months: February, 5 per cent; March, 14 per cent; April, 20 per cent; May, 21 per cent;

June, 6 per cent; August, 6 per cent; September, 12 per cent; October, 6 per cent; November, December, January, and July, inclusive, 10 per cent. These figures are fairly uniform for the whole island with the following exceptions: On the west end of the island, the September and October plantings amount to 50 per cent or more of the total for the Cabo Rojo to Ponce region. The Aguadilla-Isabela region also plants more in the fall. Twenty-five per cent of the total crops was produced in the Ponce to Cabo Rojo section, and another 25 per cent in the Aguadilla-Arecibo-Utuado triangle. The tobacco district Cayey, Caguas, Comerio planted about 4,000 acres. Yabucoa planted 1,500 acres, and Coamo 3,000 acres.

Rice (22,000 acres planted).—Planting by months: March, 4 per cent; April, 12 per cent; May, 27 per cent; June, 15 per cent; July, 18 per cent; August, 9 per cent; September, 8 per cent, and 7 per cent about equally divided between the other five months. The Yabucoa-Maunabo section had about 1,700 acres planted, and the municipalities of Barros, Cidra, and Cayey averaged about 1,000 acres each. The following municipalities ranged from 400 to 700 acres each: San Sebastian, Lares, Utuado, Villalba, Coamo, Ponce, Comerio, Bayamon, Aguas Buenas, Caguas, San Lorenzo, Rio Grande, and Carolina.

Field beans and cowpeas (118,000 acres planted).—In March, 13 per cent of the acreage was planted; in April, 18 per cent; in May, 15 per cent; and in September, 11 per cent. In June and July the plantings were light, and in the other months they were from 5 to 7 per cent of the whole each month. On the western end of the island the planting season appears to be earlier where a larger per cent than the averages was planted in January and February. In the Coamo-Juana Diaz-Ponce section the September plantings were heavier than the average. Isabela reported more than 7,000 acres, and Aguadilla, Aguas Buenas, San Sebastian, and Utuado reported more than 4,000 acres each. Arecibo, Hatillo, Lares, Ponce, and Yauco reported more than 3,000 acres each, and the following municipalities reported more than 2,000 acres each: Adjuntas, Cabo Rojo, Camuy, Carolina, Coamo, Moca, Quebradillas, and San German. Very few municipalities planted less than 500 acres, and the majority ranged from 500 to 1,500 acres. About 50 per cent of the acreage reported was planted to the white Navy type, 25 per cent or more was planted to what are called red beans, which included large and small Red Kidney and a number of types resembling such varieties as Horticultural, Red Valentine, etc. The cowpeas, planted for consumption and comprising nearly 25 per cent of the acreage, are chiefly of the Blackeye type.

Pigeon peas (23,000 acres planted).—Planting by months: February, 7 per cent; March, 13 per cent; April, 21 per cent; May, 15 per cent; June and September each, 9 per cent. In the Isabela-Aguadilla section planting was much scattered throughout the months March to October, and in the Bayamon-Guayanilla section the largest acreage was planted in January and February. The Aguada-Isabela-Utuado triangle planted 40 per cent of the total acreage, and the Cabo Rojo to Ponce section, 27 per cent. The Rincon-Mayaguez-Las Marias section planted about 2,000 acres, and the Bayamon-Guaynabo section 1,000 acres.

Sweet potatoes (55,000 acres planted).—The season for planting sweet potatoes was very evenly distributed among the 12 months, though in most places the plantings were light in December and January. The acreage was more or less uniform throughout the island. Few municipalities planted less than 300 acres, and the Isabela section planted nearly 3,000 acres.

Yautias (22,000 acres planted).—In February, 9 per cent of the acreage was planted; in March, 12 per cent; in April, 16 per cent; in May, 13 per cent; in September, 10 per cent; and from 5 to 6 per cent in each of the other months, nearly equally divided. In the municipality of San Sebastian the acreage was more than 1,000, but in most municipalities it ranged from 100 to 700. Some municipalities, such as Guanica, Lajas, Cabo Rojo, Santa Isabel, and Vieques, plant practically no yautias.

Cassava (14,000 acres planted).—The planting ranged from 800 to 900 acres in each of the months December, January, July, August, and October, and from 1,100 to 1,800 in each of the remaining months. The Aguadilla-Isabela section planted about 3,000 acres; Utuado, Guaynabo, and Bayamon, 500 each; Moca, San Sebastian, and Ponce, about 700 each. In other sections the plantings ranged from a few up to 300 acres in each municipality.

Yams (7,000 acres planted).—In January, 10 per cent of the total was planted; in February, 15 per cent; in March, 14 per cent; in April, 18 per cent; in May, 13 per cent; and 4 per cent in June. Practically none was planted in July, but from August to January the acreage increased gradually from 3 to 8 per cent. Aguadilla is the only municipality reporting more than 500 acres. Mayaguez, Moca, and Ponce reported nearly 400 acres each. San Sebastian and Utuado, more than 300 acres each, and Aguada, Anasco, Guaynabo, Lares, Las Marias, Quebradillas, and San German, more than 200 acres each. The acreage in the mountain districts east of Utuado was negligible. No yams are planted at any time in the drier sections on the west end of the island.

EDUCATIONAL WORK.

Though many of the agricultural committees mentioned in last year's report discontinued the work outlined as soon as the field service stopped, others remained active and still correspond with this office. On the whole, the effect of the effort made is yet evident in most places.

The educational effort in behalf of tick eradication resulted in the building of many dipping tanks and aroused an island-wide enthusiasm which will greatly aid in making Porto Rico tick free. Assistance was given in formulating a bill authorizing an appropriation for tick eradication which was passed by the last legislature.

CORN SELECTION.

During the earlier part of the year every field agent was requested to send in samples of corn from all districts of the island. Ears were received from about 100 localities and represented all types and colors grown. This corn was used as a basis for a lecture on corn selection. Later, as the subject became more clearly defined and the need of corn selection more apparent, a circular entitled "The Selection of Seed Corn in Porto Rico" was prepared and submitted for publication.

POULTRY.

In the food propaganda carried on during the war, special emphasis was laid upon the necessity of bettering poultry, especially chickens. Information on poultry raising was widely circulated, and the result was very encouraging. This year a circular entitled "Poultry Keeping in Porto Rico" has been prepared and submitted for publication.

AGRICULTURAL EXTENSION NOTES.

After the war-time agricultural work was discontinued, a special effort was made to keep in touch with at least a portion of the large rural population. For that purpose it was decided to publish timely information at short intervals. February 1 a start was made by sending out the first mimeographed issue which contained probably 1,000 words. Since then issues containing from 800 to 1,000 words, and written in English and Spanish have been sent on the 1st and 15th of each month to those who desired them. Up to the present time, however, it has been found difficult to maintain the mailing list, because many people who live far from a post office have never had mail delivered to them. This difficulty has been overcome by an arrangement which was made in the fall with all the school supervisors and

the special teachers of agriculture who have agreed to attend to the distribution of mail through the rural schools.

AGRICULTURAL LECTURES.

By the action of the last session of the legislature, the staff of special agricultural teachers was increased so as to provide one man for each school district except San Juan, which is entirely urban. This increase has proved a matter of very great importance to the island, for no other department is so closely in touch with the rural population. It will also prove of great importance to this office, as cooperative effort enables both the station and the school staff to gather much data and to disseminate knowledge among a class of people whom it would be difficult to reach in any other way.

It is manifestly impossible for one man to reach upward of a million people by word of mouth. Helpful suggestions to the special teachers of agriculture and the rural school teachers should, therefore, accomplish a great deal of good. Many people, however, do attend the fairs and agricultural meetings and take advantage of all opportunities which are offered them. By means of a light truck it has been found possible to carry for such purposes demonstration material of all kinds, including a projecting lantern and slides, charts, and sometimes a crate of purebred pigs, chickens, etc., as well as a good supply of literature for distribution.

FARM MANAGEMENT WORK.

As this branch of the station is in closer touch with fruit growers than with producers of any other export crops, being located in San Juan, it was natural that a farm survey should be first undertaken in the fruit districts. Very little was accomplished in the field until August 1, 1919, when a light truck was transferred to the station from the War Department and it became possible to carry out plans which had been pending for a long time. These plans comprise a survey of the fruit districts to determine the influence of soil, environment, and general treatment on stock and variety measured by the size and health of the tree and the quantity and quality of the fruit.

The financial aspect of citrus growing was taken up at the beginning of the fiscal year, but inasmuch as no one was found who could supply the necessary figures, a set of forms was prepared and a few samples sent out for trial. A number of helpful suggestions have been since received, and in a short time it will be possible to publish information which will answer local needs on cost accounting.

REPORT OF THE AGRICULTURAL TECHNOLOGIST.

By W. A. MACE.

During the year investigational work was continued with rice, soy beans, and cowpeas. Work was also started with the mungo, or mung, bean (*Phaseolus mungo*). The planting of corn from the Virgin Islands did not prove a success last season. The yield was not so good as that from the selected seed of Porto Rican corn. The Virgin Islands corn is softer than the Porto Rican varieties and is much more readily attacked by weevils.

A large quantity of Napier, or elephant grass (*Pennisetum purpureum*), cuttings have been distributed among the planters of the island for propagation as a forage crop. Some of the planters have devoted large areas to this plant, which seems to be giving very satisfactory results. Napier grass is beginning to be considered of great value as a stock food, especially where dairying or stock raising is carried on, and it also serves as feed for work oxen on some of the sugar-cane plantations.

The spring planting of the rice nursery, where studies of the individual varieties and of cultural methods are made, was delayed this year, owing to the lack of water for flooding the field. However, it is hoped to make a late planting, and after this season to have an adequate water supply for carrying on this work so that two plantings can be made each year. Records showing date of seeding tests were continued, but conditions for making determinations have not been ideal, owing to insufficient water for keeping the plats flooded uniformly, and the records are, therefore, not entirely representative. The studies in rice irrigation have also had to be postponed. An irrigation system which it is hoped will supply sufficient water for carrying on the experimental work and for studying the different phases of rice culture necessary for the industry on the irrigable lands of Porto Rico is now in progress of construction by the station.

The total area of lands on the hillsides in Porto Rico, which are devoted to small plantings of rice, is of such proportion as to make important a study of the different varieties, conditions, and methods, with a view to improving this phase of the rice industry. For this reason, a collection has been made of the rices grown in the different parts of the island. These, numbering 145 samples, including numerous varieties, have been planted in a nursery at the station for study and comparison. In this nursery one variety of Honduras and one of Japanese rice are being used to serve as checks for this work. It is hoped to make another planting of these rices later in the season.

The rice work carried on with the planters in different parts of the island is being continued for making cultural tests and for demonstrating the use of machinery in this industry. While the plantings were not so numerous as those made last season, it is hoped that better general results will be obtained from this year's work.

Owing to the heavy rains of the summer it probably will be impracticable to use machinery, except on very rare occasions to harvest the spring crop. However, there is every reason to believe that the fall plantings can nearly always be handled with machinery. The only difficulty to be encountered in fall plantings is that of using the seeder in the rainy season, since the plantings must necessarily be made during the time when rainfall is heaviest. It is believed, however, that this can be worked out satisfactorily.

Variety tests, rate of seeding, and date of seeding tests are being carried on with cowpeas, soy beans, and mungo beans.

Good results have been obtained from the mungo, which seems of such importance as to be well worthy of further study both in regard to the plant and the various phases of culture necessary for its adoption as one of the principal food crops of the island. It is hoped that a large distribution of seed can be made for planting in the coming spring. This crop should prove to be very valuable to the small planter as it resists drought and excessive rains much better than the ordinary bean. It is hoped that it may attain the same position with the small planters here that it has attained in the Orient, where it is one of the principal food crops.

The dipping of the station cattle for the eradication of the cattle tick was continued with very satisfactory results. A large number of cattle from the vicinity of the experiment station have been brought in to be dipped and several dipping vats have been constructed on the island. Requests for information regarding the construction of vats and methods of procedure in the eradication of the tick are frequently received.





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PORTO RICO AGRICULTURAL EXPERIMENT STATION,
D. W. MAY, Agronomist in Charge,
Mayaguez, P. R.

**Under the Supervision of the STATES RELATIONS SERVICE,
Office of Experiment Stations, U. S. Department of Agriculture.**

**REPORT OF THE PORTO RICO
AGRICULTURAL EXPERIMENT
STATION.**

1920.



Issued July 19, 1921.



**WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1921.**

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PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director, States Relations Service, United States Department of Agriculture.]

E. W. ALLEN, *Chief, Office of Experiment Stations.*

WALTER H. EVANS, *Chief, Division of Insular Stations,
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LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., October 18, 1920.

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Porto Rico Agricultural Experiment Station, 1920.

Respectfully,

D. W. MAY,
Agronomist in Charge.

Dr. A. C. TRUE,
*Director, States Relations Service,
U. S. Department of Agriculture, Washington, D. C.*

Publication recommended.

A. C. TRUE, *Director.*

Publication authorized.

E. T. MEREDITH,
Secretary of Agriculture.

¹ Resigned Aug. 10, 1920.

² Resigned Aug. 26, 1920.

³ Appointed Sept. 7, 1920.

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REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1920.

REPORT OF THE AGRONOMIST IN CHARGE.

By D. W. MAY.

INTRODUCTION.

During the fiscal year 1920 Porto Rico experienced the greatest prosperity it has ever known. The crops generally were good and the prices received for them were high. Not only was trade with foreign markets far greater than ever before, but living conditions were very much improved owing to the increased production of food for home consumption. External trade amounted to \$247,200,000, approximately \$150,000,000 of which represented material exported from Porto Rico. This was an increase of \$70,000,000 in exports over the previous year. Products imported were valued at \$96,000,000, which was a gain of \$34,000,000 over 1919. This shows a balance of trade largely in favor of the island.

SUGAR.

The sugar exported from Porto Rico in 1920 showed an increase of 68,000 tons over the amount shipped last year. The average price obtained per ton was almost \$100 greater than the price per ton in 1919. This represents an average of 11½ cents a pound, or a gain of 4½ cents a pound in 1920. It is not likely that such high prices will continue, and planters need to prepare to meet the situation that may be caused by a fall in sugar prices by making a thorough study of their business now. As a preliminary step the land should be put in systems of rotation. The lands in Porto Rico have been kept in cane too long. The old method of allowing them to grow up to pasture for two years or more is no longer followed because of the increased value of land and the great demand for sugar.

It is difficult to get Porto Ricans to plant cane in rotation with other cultivated crops. The station has made great efforts to induce them to grow rice in rotation with cane. This crop, however, requires special irrigation of the land and machinery for seeding, flooding, harvesting, and thrashing. While labor is abundant and

reasonably cheap, rice can not be grown here by oriental methods; and it does not seem possible at present to get planters to put in machinery needed for rice cultivation. During the past two years some attempts were made to grow rice, but the effort was only half-hearted and spasmodic, owing to the fact that the sugar crops brought greatly increased prices. A few crops of rice have been grown here and there, but the land has invariably gone back to cane. Legumes give great promise as a rotation crop with cane. The growing of beans in the young cane is a practice that will probably be continued by the laborers. The station has introduced some other legumes which are better adapted to land that is broken after cane and wholly devoted to the new crop. The velvet bean is one of the more promising sorts, as it not only improves the soil but provides excellent forage for the work animals. Another legume that is giving splendid results is sunn hemp (*Crotalaria juncea*). This crop has given enormous yields within a very short time.

Cane is usually planted in the winter time and harvested the following winter. There is a practice followed here, however, of planting the cane in the summer and carrying it over for 15 or 18 months before harvesting it. Where ratoon cane is cut for the last time in the winter, the land should be broken and planted to *Crotalaria*, which may be pastured and turned under in the summer. Cane should then be planted and allowed to grow for 18 months before it is cut. In this way a great deal of organic matter and nitrogen can be returned to the soil without any great interruption to the sugar-cane crop.

In general, it may be said that the yield of sugar could be greatly increased on the average farm in Porto Rico were more and better cultivation given the land. Owing to the fact that the cultivation of cane lands is at best an expensive affair, it would be well to do more plowing and less hoeing, and to stir the soil frequently. More than \$3,000,000 was paid during the fiscal year 1920 for imported fertilizer, most of which was applied to the cane crops. A great deal of this fertilizer was bought to very poor advantage, and in many instances it failed to fill the most urgent need of the field to which it was applied. Every planter is advised, therefore, to make a closer study of the requirements of the various types of soil. Fertilizers are always more or less uncertain, and it is well to learn what rôle they play in the production of a crop and what effect they have on the soil to which they are applied.

The future of sugar cane, the principal crop of Porto Rico, has generally been overshadowed by a cloud. First, it was the changa or West Indian mole cricket and the May beetle, then a fungus disease, and last, the mottling or mosaic disease. However, these difficulties have been considerably controlled by natural and artificial

measures. The mosaic disease of cane showed less virulence during the past year, although it is still a factor to be reckoned with. This disease has been combated largely by the introduction of immune or partially immune varieties. Some varieties, such as the Kavangire, a cane of the Japanese type (Pl. VI, fig. 2) appear to be wholly immune. Other varieties, including many seedlings produced on the island and some brought from Java, are partially immune, and, though showing some symptoms of the disease, make a good growth and produce large yields in spite of it. Roguing fields of the infested stools gives economic results where there is only little disease present.

The work of the station with sugar cane has been largely a matter of growing new varieties from the seed in the tassel. This method gives a greater return for the time and money expended than any line that can be followed consistently from year to year. The new varieties produced are legion. By continually eliminating the unfit and least productive plants, the station hopes to develop varieties that will be less susceptible to disease than the cane now grown in Porto Rico. It also aims to secure varieties giving greater tonnage and larger sugar content than is now obtained.

LIVE STOCK.

One of the most promising lines of agriculture is the production of live stock, yet this industry is very poorly developed in Porto Rico. No system of agriculture is complete or well grounded unless it includes within its scope the production of animals. Even in cases where a country produces a specialty for a certain market, as, for example, the Channel Islands, which grow potatoes and tomatoes for trade with London, live stock is needed to consume the waste products of the farm and to conserve the fertility of the soil. The present practice of growing only one remunerative crop without certain necessary adjuncts, such as animal farming, is unsafe, too often unprofitable, and is not rounded out, perfected agriculture. At present there is not enough poultry produced in Porto Rico to supply local demands. Very few farmers produce enough hogs to meet their own needs. In fact, there are not enough pigs on the island to utilize kitchen waste. The pork and lard imported into Porto Rico during the year amounted to more than \$3,500,000. Such an enormous expense would be saved were the pig stock increased and improved. This could be brought about by growing throughout the year forage and other crops especially for hogs and by fencing in the hog pastures. The time has passed when growing pigs should be tied out with a rope or kept penned up. Fencing should be provided for them and crops kept growing so that the animals will not need imported concentrates. A rotation of pastures and even fruit

and coffee groves would provide an excellent means for increasing pig production, and at the same time it could be handled in such a manner as to improve the condition of the soil and conserve labor.

A considerable number of purebred cattle were imported into Porto Rico during the year. As cattle tick and tick fever are found throughout the island, great caution should be exercised about bringing in purebred cattle. In the first place it is impossible to turn such cattle into the fields and expect them to prosper as native cattle do. They must be kept stabled and as far as possible be kept free from ticks. Unless the farmer is prepared to do this he had better confine his purchases to a purebred bull to upgrade his herd. Porto Rico has an excellent race of native cattle. They have not been bred for any special purpose. Their conformation is good, but could be improved in a few generations by judicious crossings with improved breeds, the breeder following the lines he desires. The herd can be bred for milking qualities or for beef production or reproduced with a view to maintaining ability to work. Strong work animals will be needed on the plantations for years to come. A good many tractors are being sold on the island, yet the ox must do certain work, and does it at less cost than would the tractor, the horse, or the mule. The work oxen are capable of maintaining themselves on the poorest grasses and under rather harsh treatment and can not well be dispensed with.

Of late years the tendency in breeding cattle has been toward the dairy type. In improving the herds for milk yield it should be remembered that the male offspring must be employed as work animals. For this reason there should be selected a breed which will cross well with the native stock, improve the milk yield, and also produce strong work animals for the plantations. The station has developed a herd of Guernsey cattle (Pl. I, figs. 1 and 2). This breed is somewhat similar to the native stock in form and color, and the resulting crosses are not only showing greatly increased dairy capacity, but they are strong, stocky, and apparently well adapted to working. Moreover, the breed has short hair, which affords less protection for the cattle tick.

The great drawback to the cattle industry in Porto Rico is the cattle tick. This pest, in addition to carrying tick fever from animal to animal, greatly saps the strength of the individual by sucking its blood. Were it eliminated, the cattle industry should make wonderful progress in a short time, and no doubt a race of cattle could be developed here as famous as those of some other countries where special purpose animals are produced. About 50 dipping tanks, modeled after the first tank established by the station several years ago, are now located in various sections of the island. Others are



FIG. 1.—STATION GUERNSEY BULL.



FIG. 2.—GUERNSEY NATIVE HEIFERS.

being built. The public is rapidly awakening to the wisdom of freeing the animals from the ticks and to the necessity of ultimately exterminating the pest altogether. As soon as enough tanks are available and the public is made to understand their value, so that a campaign to raise the necessary appropriation can be carried on, the elimination of the tick will be taken up and brought to a successful issue. From an agricultural standpoint, money could hardly be more wisely expended. Until the cattle tick is exterminated there will be no full development of the cattle industry, upon which the agricultural prosperity of the people of Porto Rico depends to a great extent. Porto Rico is a country that should produce not only for its own requirements but also for those of other countries, yet the dairy products imported during the fiscal year 1920 amounted to more than \$1,750,000.

FRUIT.

The amount of fruit exported during the year ended June 30, 1920, was approximately the same as in 1919, but the prices paid for it were somewhat higher, totaling \$2,645,000. The industry was affected by the lack of shipping facilities, and much fruit was lost because it was impossible to get it to market. When more pineapples are produced than can be marketed the fruit is usually handled to advantage by the canneries. A nonshipment of oranges, however, invariably results in great loss to the growers. This year Porto Rico produced a surplus of grapefruit, which was taken care of to some extent by a factory organized by the planters for bottling the juice.

The fruit industry has been developed since the American occupation; that is to say, within the last 22 years. In the early years of the industry it suffered considerably from exploiting companies which did not deal fairly with the investors. At present it is greatly handicapped by inadequate shipping facilities. Not only is the fruit delayed in being transported, but in many cases it is refused transportation because of lack of space on the steamers. The planting of fruits is greatly lessened at present, though its position as an industry is assured. The industry would be greatly furthered by a better cooperation among the growers. Efforts made to bring this about are proving successful. Closer cooperation will enable the planters to make a better study of their problems, secure better shipping facilities, and bring about better marketing conditions, which may result in greater appreciation of the quality of the fruit grown in Porto Rico.

One of the greatest handicaps of the fruit industry is the lack of uniformity and standardization of the product. Too many green pineapples have been shipped from Porto Rico. The Porto Rican

orange is still a nondescript. The wild orange is shipped in large amounts and is probably the type that is best known in the markets of the States. When cultivated fruit is shipped it has to compete with the wild fruit and suffer from the defects of the latter. Too much spoiled grapefruit has been exported from Porto Rico. This has resulted in loss in shipment and has helped decrease the price of good fruit. The fruit industry in Porto Rico has greatly suffered from the marketing of unripe fruit. Fruit that is produced before or after the normal season naturally brings a higher price than fruit that is grown in season. In an endeavor to reach this market many growers in Porto Rico have ripened their fruit by artificial means, or have given it the appearance of being ripe by sweating it. This process produces a beautiful coloring of the skin, but it does not make an unripe fruit edible. As a result of this deception, the value of the grapefruit has been lessened and its consumption has been greatly reduced. This practice was begun by only a few planters, but was soon followed by other growers who were attracted by the temporary profits it brought. Finally, at the solicitation of the planters themselves, a standard was established under the Food and Drugs Act for the purpose of stopping the shipment of immature fruit. It has not been very effective, however, owing to the difficulty of determining the standard and the hesitancy of applying the law in individual cases. The fruit growers of Porto Rico can not expect to obtain the profits that should accrue from the fruit industry unless they establish a good reputation and maintain it through honest cooperation.

TOBACCO.

The growing and manufacturing of tobacco was enormously increased during the year. The value of the exports of cigars, cigarettes, and leaf tobacco approximated \$25,000,000, more than half of which was for tobacco in the manufactured form. A distinct gain in the quality has been brought about by better cultural methods, and especially by improved means in curing and fermenting. This feature, together with the increased demand for tobacco everywhere, naturally has caused the price paid for it to be much higher than formerly. The industry is confined largely to certain interior valleys and surrounding hills. However, areas are being developed in other sections where tobaccos of fair quality are being produced. The industry is capable of great expansion, and many soil types may yet be found that will produce an excellent quality of leaf. A soil survey of the tobacco lands should be made, since it would no doubt result in greatly furthering the production of the crop.

COFFEE.

Of the coffee exported during the fiscal year 1920, \$8,769,000 worth went to foreign countries and only \$265,000 worth went to the States. The shipments were over 4,000,000 pounds in excess of the coffee exported in 1919. The average price received per pound was 27.6 cents, or an increase of 5.9 cents over the returns of the previous year.

The increased production of coffee was due largely to improved methods of cultivation and not to any great number of new trees coming into bearing. Though the year was considered a prosperous one for coffee, this industry has probably reached the zenith of its importance as a crop in Porto Rico. Owing to the ease with which it may be kept and marketed, the crop competes with the coffees of the most distant countries of the world. In Porto Rico the tendency is to grow crops bringing the highest prices in a market that can be reached within five or six days. On account of the proximity of the island to the eastern coast of the States, where most of its produce is sold, Porto Rico has less competition in certain perishables than other countries not so well situated. Nearness to market, therefore, gives perishable products an advantage over those than can be stored for a long time and transported over a long distance.

The most favorable outlook for the coffee grower is along the line of diversification. The time has passed when the planter could depend upon his coffee crop to bring him a large profit to meet his annual bills. He is continually faced with a decreasing production of coffee and a fluctuating and lowering market, as well as with direct competition with cheaper and more fertile lands. Moreover, since in certain of these coffee-producing countries the lands are undulating, the groves may be cultivated with plows; while the Porto Rican planter must continue to cultivate his mountain lands with the hoe or machete.

PLANT INTRODUCTIONS.

The station, in cooperation with other tropical stations and the United States Department of Agriculture, continued to introduce economic plants from various countries of the world. These cover a wide range, from varieties of plants of great economic importance to other plants that may prove of value for local consumption or exportation. Still others are for ornamental use only. The station has sought legumes that will improve the soil and provide forage for live stock, shade for coffee, and minor crops. A number of these are listed and described later in this report. Under forage crops

the velvet bean (*Stizolobium* sp.), sunn hemp (*Crotalaria juncea*, Pl. II, fig. 1), and Napier or elephant grass (*Pennisetum purpureum*, Pl. II, fig. 2) are worthy of extended planting. The elephant grass grows on low and high lands, can be cut several times during the year, and yields enormously. A recent cutting from a plat of four years' standing gave a yield of 12.8 tons per acre. A plat on high land cut for the first time 7 months and 10 days after planting yielded at the rate of 19.33 tons per acre. This grass is greatly relished by cattle and may be fed either as a soiling crop or pasture. Japanese cane will also be valuable as a forage crop. This cane is wholly immune to the mosaic disease and is being extensively planted for grinding for sugar. Even should more productive immune varieties be found, the Japanese cane will be invaluable as forage because it grows on high lands. Many of these lands are not planted now and produce only a meager amount of pasture.

The station is still sending out thousands of forest and ornamental trees, shrubs, and plants (Pl. III, figs. 1 and 2). While it is hard to estimate the value of this work, it is gratifying to note that the various introductions are benefiting and pleasing the people in all sections of Porto Rico.

The correspondence of the station shows a notable increase over last year's, especially in the matter of requests for information from planters in all parts of the island. The people are rapidly learning that the station is solely for their benefit, and that it stands ready to give them advice or suggestions on the various problems arising from time to time.

LIVING CONDITIONS IN PORTO RICO:

From the standpoint of beauty of surroundings and equable climate, country life in Porto Rico is ideal. The continued building of good roads and greatly facilitated means of communication between neighboring towns and villages has made life in all outlying districts much more attractive than formerly. Housing and living conditions generally have improved among plantation owners, but there is seldom, if ever, any change in conditions among the poorer classes.

Porto Rico continues to increase in population. The decennial census just closed reported a total increase of 15 per cent over the last census. At present there is an average of 377 persons to the square mile. In fact, the population has increased in numbers as fast as the agriculture of the island would permit. The actual wants of the laboring classes, or peons, as they are called, are few and simple, yet in many cases they lack the necessities of life.



FIG. 1.—*CROTALARIA JUNCEA* AS GREEN COVER CROP IN MANGO ORCHARD.



FIG. 2.—NAPIER OR ELEPHANT GRASS, 10 MONTHS' GROWTH.



FIG. 1.—INTRODUCED PALMS, CORYPHA, FISHTAIL, AND SUGAR PALMS.

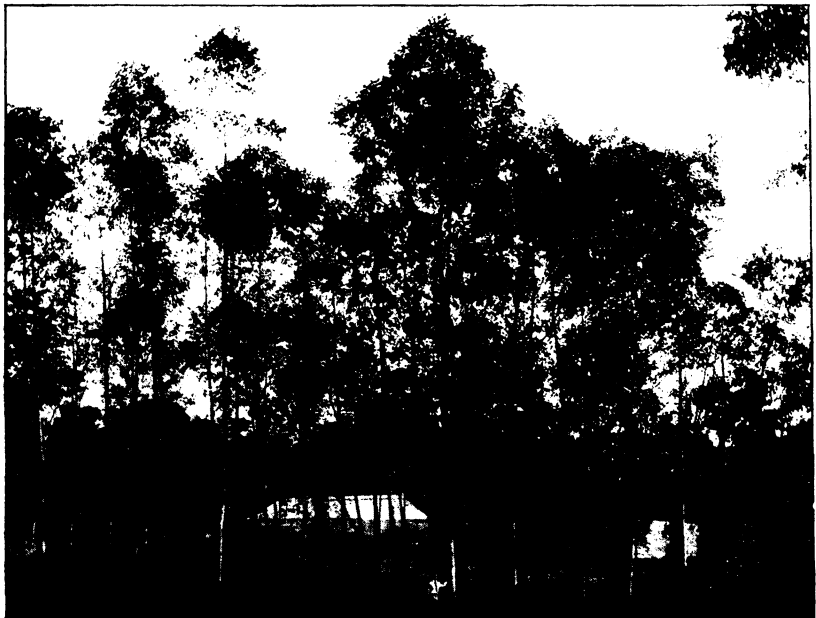


FIG. 2.—EUCALYPTUS ROBUSTA, 8 YEARS OLD.

Labor is so plentiful in Porto Rico that laborers can not demand a living wage. Many of the plantations, especially in the interior of the island, are overrun with them, and often the plantation owners consider them a detriment rather than an aid. The peons construct on the plantations little shacks made from palm leaves or other local material. They pay no rent for the use of these shacks and often build them without the permission of the landowner. Public sentiment frequently looks upon the plantation owner as an oppressor, but in many cases he can do nothing to justify his paying a living wage to all the peons living on his place. They will not embark in ordinary farm practice, such as gardening or poultry raising, because of the fear that their produce will be stolen. The average laborer is not aggressive and can not well protect his own property and interests. Moreover, he is very hospitable and is as a result greatly imposed upon by relatives and friends. These people are practically tied to the plantation on which they live. They will not emigrate and they have no ambition.

The prosperity of the country has been dependent upon agriculture for five centuries, and no doubt will continue to depend upon it for many years to come. Porto Rico will hardly become a manufacturing country, because it has no coal and very little water power. Conditions have greatly changed throughout the island within recent years, but there is room for greater improvement. This can not be brought about, however, until the greater number of people now owning no land are better housed, fed, and clothed.

REPORT OF THE CHEMIST AND ASSISTANT CHEMIST.

By L. G. WILLIS and J. O. CARREBO.

RICE INVESTIGATIONS.

During the year the greater part of the work of the chemical department dealt with the determination of the factors governing rice production. Special attention was given to the study of the relation of fertilizers and soils to the apparent physiological reaction of the plant. Many series of pot experiments were conducted, and the crops were analyzed where it was thought probable that the results would be of value.

It was found that potash is apparently not a limiting factor in the soils chosen for the work and that phosphates have a tendency under some conditions to cause a chlorotic condition of the plant due to faulty assimilation of iron. Since this observation was made on a basic soil only, it is probable that the added phosphate and the basic material in the soil were concerned in the production of chlorosis.

However, it is not certain whether the result was due to precipitation of iron in the soil or to interference with the normal distribution of iron in the plant. A difference was also noted in the response of the plant to different forms of phosphate fertilizer that is not explainable as being due to difference in availability. The different phosphates varied considerably in their tendency to produce chlorotic rice.

Tests of different forms of nitrogen for rice seemed to indicate that the results vary according to the reaction of the soil. Ammonium salts, except ammonium phosphate, were decidedly preferable for neutral or basic soils, and the nitrates gave the best results on acid soils. In practice, however, it is probably better to apply lime to acid soils in proportion to the degree of acidity, and to use ammonium sulphate as the source of nitrogen.

Determination of hydrogen-ion concentration in the extracts of the soils used in several pot experiments indicated that there is some intensification of acidity in the soil extract due to ammonium sulphate in comparison with that due to sodium nitrate. Phosphoric acid applied as such (H_3PO_4) to a basic soil gave good increases in yield. In case of acid soil the size and thriftiness of the plants increased with the amounts of phosphoric acid added, even though the actual acidity of the soil extracts (as shown by colorimetric hydrogen-ion determinations) was increased by such applications.

Apparently carbon dioxide was the acid most active in governing the soil reaction, since the hydrogen-ion concentration of the soil extract was lowered on exposure to the air, and iron and lime were precipitated.

Publication of the results thus far obtained in this investigation has been delayed on account of the complexity of the factors involved. It is hoped, however, to have results soon that will permit at least a preliminary report of the data recorded.

MANAGEMENT OF CANE SOILS.

The study of nitrogen economy in cane soils was carried on during the year as planned. It became necessary to relocate the plats after a preliminary test because the original area was not sufficiently uniform for the purpose of the experiment. However, the plats have now been laid out on the new tract, samples taken, and treatments applied, and the first green manure crop has been planted. This investigation is expected to yield quantitative results on the effect of lime, leguminous cover crops, different forms of nitrogenous fertilizers, and different methods of disposal of the cane residue on nitrogen utilization, conservation of soil organic matter, and soil reaction.

MISCELLANEOUS ANALYTICAL WORK.

Some analytical work was done for other departments of the station, including the analysis of over 300 seedling canes that are being tested by the plant breeder.

The department continued to make analyses of materials sent in from various sources when it was thought that the results would better general agricultural conditions. The greater part of this work consisted in testing cave deposits for their fertilizing value and soils for acidity. Recommendations were made as to the use of various fertilizers, the management of soils, and the application of lime.

REPORT OF THE HORTICULTURIST.

By T. B. McCLELLAND.

LEGUMES.

The variety tests of beans were continued, more than 40 distinct varieties being included and nearly 12,000 feet of bean rows being planted. These tests showed as a general rule that, under favorable conditions, much greater dependence for a crop can be placed on varieties previously grown in the Tropics than on those imported from the North. Both the Porto Rican white bean and the Venezuelan black bean are notable for heavy yields. Accidental crosses evidently have occurred in the field, and in many cases the progeny is being carefully watched. More than 500 selections were studied individually. Some of these appear very promising. White, straw, yellow, brown, pink, red, purple, and variegated beans developed from the Venezuelan black. Since the Porto Rican market objects to the black color of this very prolific bean and it is sold at a greatly reduced price as a result, it is hoped that something of value will be found among this lot when the pure lines are established. A very interesting case of variegation appeared in the plantings of Venezuelan black beans. On the same plant were borne some pods containing only straw-colored seeds, other pods containing only purple or lavender seeds, and still other pods having seeds of both colors. In some cases a single seed showed both colors. Other plants produced straw-colored seed only, or purple seed only, but it remains to be seen which of these breeds true to color.

Pigeon peas have been under test at the station for several seasons. When planted in the spring and picked green at frequent intervals from December to May, they yielded at the rate of 906 liters, weighing 1,246 pounds, per acre. A contemporaneous planting, in which the seeds were allowed to mature before picking, yielded at the rate

of 495 liters, weighing 900 pounds, per acre. A spring planting of the year following, in which only a single picking was made at the end of the season, yielded less than half as much as the preceding crop.

Seeds from plants producing green, mottled, and red pods were planted separately, yet a very mixed progeny developed, especially from the green-podded plants. The red-podded plants came much truer to color than the green-podded, though they were not entirely true. In a comparative test of native selections and a red-seeded variety received from Cuba, the former proved much more prolific than the latter.

For purposes of comparison a planting was made in March of several leguminous cover crops, including *Tephrosia candida*, *Canavalia ensiformis*, *Crotalaria juncea* (Pl. II, fig. 1), *Stizolobium velutinum*, *S. aterrimum*, and the bush velvet bean. At the end of 10 weeks all had developed a fairly good stand, the *Crotalaria* and bush velvet bean having made the best development. When the *Crotalaria* had reached a height of 4 feet, the *Tephrosia* measured only 7 inches or less in height. At the end of 17 weeks the *Crotalaria* began to blossom and stood 8 or 9 feet high, the bush velvet beans were 2 feet high, and the others were from 2 to 2½ feet high. The *Tephrosia* was extremely spindling at this stage, but in each of the other varieties representative sections of the field were cut at the surface of the ground and weighed. All rows were spaced 3 feet apart. The seed had been planted 8 inches apart in the row, except the *Crotalaria*, which had been closely dropped in the row. The green weights calculated to the acre were *Crotalaria juncea*, 12.6 tons; *Stizolobium velutinum*, 9 tons; *S. aterrimum*, 8.8 tons; bush velvet beans, 7.5 tons; and *Canavalia ensiformis*, 5.4 tons. After a period of 25 days, during which time plants were spread on trays and sunned, the weights were reduced to 3.0, 1.3, 1.4, 1.4, and 1.0 tons, respectively.

COFFEE.

The main lines of investigation followed in the past with coffee and cacao are still in progress. Robusta and closely related sorts of coffee have been very prolific in favorable locations and offer certain advantages over the locally-grown Arabian coffee. Sixty samples of Robusta coffee were sent to local consumers for cup testing. The opinion of the recipient was requested as to whether the coffee was considered of poor, medium, or good quality; inferior, equal, or superior to the Porto Rican coffee; and whether it should be planted in Porto Rico. Twenty-one replies were received, though some were incomplete. One consumer considered its cup-quality poor, ten consumers considered it medium, and ten good. Fourteen considered it

inferior; six, equal to, and one, superior to, the Porto Rican coffee. Nine thought it should be planted locally, and ten thought it should not be grown in Porto Rico.

About 2½ years from the beginning of the cooperative experiment undertaken for the control of the coffee-leaf disease (*Stilbella flavida*) heretofore mentioned,¹ an overzealous foreman replanted a large part of the plat with badly diseased seedlings. As soon as this was discovered an attempt was made to remove as much of the diseased material as possible. Control measures, however, were rendered uncertain by these diseased seedlings. Up to this time they had been most effective.

VANILLA.

The 1917 vanilla crop from 0.1 acre planted in 1912-13 has been reported in detail.² The yield of each crop showed an increase over the preceding. In 1918 this increase amounted to more than 27 per cent, while the 1919 crop nearly equaled the total of the two preceding crops. The appearance of the vines suggests that the maximum yield has been reached and that much smaller crops from them are to be expected from now on.

The 1918 crop, cured and stored for a year from time of picking, was very favorably reported on by dealers to whom samples were submitted. Many considered it to compare favorably with the best cures on the market. It sold for \$3 a pound.

Experimental work in curing is being continued. Limitation of production continues to show a pronounced effect on the size of the bean. In a test of the effect on production of pruning the vine tips and of shading heavily, both the pruning and the very heavy shading reduced the crop in a 3-year-old planting. Where the supporting trees were kept closely pruned to allow as much sunlight as possible to reach the vines, the unpruned vines gave three times as great a crop as the pruned and densely shaded vines and more than twice as great a crop as where there was but a single variant factor, either heavy shading or pruning. On account of the frequent weeding, the unshaded plat required much more labor to keep it in order than the shaded plat, where weeding was unnecessary.

In January the horticulturist made a trip to Guadeloupe to study vanilla plantation and curing practices. Various plantations and the largest curing establishments were visited. Though there are some large plantations, the crop is produced mainly by small farmers. These men sell their produce green or partially cured to others who cure and export the beans. A common practice with plantation owners is to turn over a definite area to a laborer to plant. When

¹ Porto Rico Sta. Rpt. 1918, p. 11.

² Porto Rico Sta. Bul. 26 (1919).

the vines reach a producing age the laborer is paid an agreed sum. After receiving this sum, the laborer must turn in half the crop to the owner and sell him the other half at the prevailing market price.

The best beans were said to be produced at considerable elevations. One plantation ranged in elevation from 1,200 to 1,700 feet above sea level, and the owner preferred the beans produced on the higher parts of the plantation. The temperature was lower and the annual rainfall heavier than at this station.

Since the whole cluster is clipped at harvest time, many beans are removed before they have a chance to mature. This has a bad effect on the quality of the cured product. The preferred curing process consists mainly in alternate sweating, closely wrapping the beans in blankets, and fully exposing them to the sun when spread on blankets. Sweating vaults heated with steam coils are used to advantage in one establishment. The curing is finished indoors on airy shelves of wire screening.

MANGO.

In the past year the Fernandez mango, S. P. I. 19117, fruited for the first time in the station orchard (Pl. IV). Not only is it a beautiful and delicious fruit, but the lateness of its season adds to its value. Its crop ripened from mid-August to early October, when few or no other mangoes are to be had. At the beginning of the Fernandez season, Itamaracá and Sundersha were the only other imported varieties to be found in any quantity, but both had disappeared before the Fernandez season was over.

The general form of the Fernandez is ovoid; in cross section, round or slightly oval. The fruits examined weighed from 222 to 405 grams. The color is a marbled green and yellow, or a pale, dull, or greenish yellow, which becomes more intense near the base. The blush may be pink, rosy red, or bright orange red, and extends from over one-quarter to one-half of the fruit. The appearance of an otherwise beautiful fruit was marred by black or purplish disease spots and splotches, which were particularly numerous around the base. The skin is moderately tough and thick. It sticks so tightly that it breaks on peeling and tears the flesh of the fruit. The flesh is juicy and pale to medium yellow. Some fruits show fiber discolorations, but not actual fiber from a blackened base. The texture is good to excellent. The aroma is delicate but delicious and the flavor is sweet and somewhat peach-like. Were it not for disease the quality would be excellent. Very short, soft fiber is thickly set over the whole seed, giving it a woolly effect. It is too short to be objectionable, except on the basal half of the ventral margin of the seed, where the fiber is one-half inch long.

This variety was considerably affected by a disease causing blackening and rotting of the stem end and the formation of a cavity between the base of the seed and the base of the fruit. Provided it does not prove to be too much subject to disease, it will be a valuable acquisition.

MISCELLANEOUS INTRODUCTIONS.

Additions have been made to the avocado varieties already planted in the orchard on Las Mesas.

A small vineyard has been set with grape varieties found locally and with others introduced from the Virgin Islands.

Carica sp., S. P. I. 46321 and *Carica papaya*, S. P. I. 46334 were tested during the year. The former appears quite valueless as an edible and the latter is very insipid in taste, though it is a large fruit and makes a handsome appearance. Some fruits weigh more than 10 pounds (Pl. V).

The writer introduced two rather promising vegetables from Guadeloupe. One is a squash which is similar in shape to the vegetable marrow, but used when only 3 or 4 inches long. The other vegetable, Stringless Bonavist (*Dolichos lablab*), is a bean-like plant having broad, sweet pods similar to those of the English sugar peas. The pods are picked when young and cooked like string beans. Both of these vegetables seem acclimated.

REPORT OF THE ASSISTANT HORTICULTURIST.

By J. P. GRIFFITH.

VEGETABLES.

Practically all of the common vegetables of the Temperate Zone were tried out at the station in the course of the year. Those principally tested included tomatoes (12 varieties), onions (7 varieties), kohl-rabi, cabbage (3 varieties), collard, cauliflower, eggplant (3 varieties), pepper (5 varieties), cucumbers (3 varieties), lettuce (7 varieties), watermelons (4 varieties), muskmelons (4 varieties), squash (6 varieties) okra (3 varieties), Lima beans (2 varieties), peas, beets (4 varieties), carrots (4 varieties), turnips (2 varieties), radishes (4 varieties), sweet potatoes (7 varieties), sweet corn (6 varieties), Stringless Bonavist bean, Irish potatoes (3 varieties), peanuts (7 varieties).

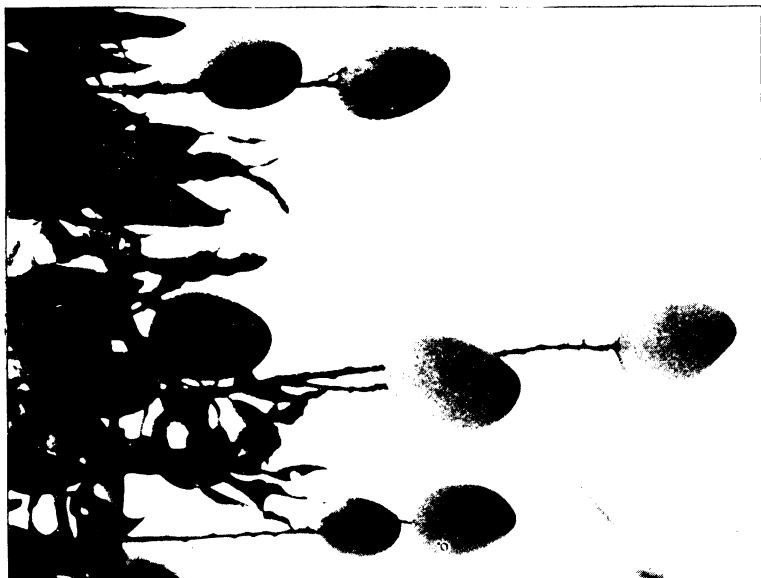
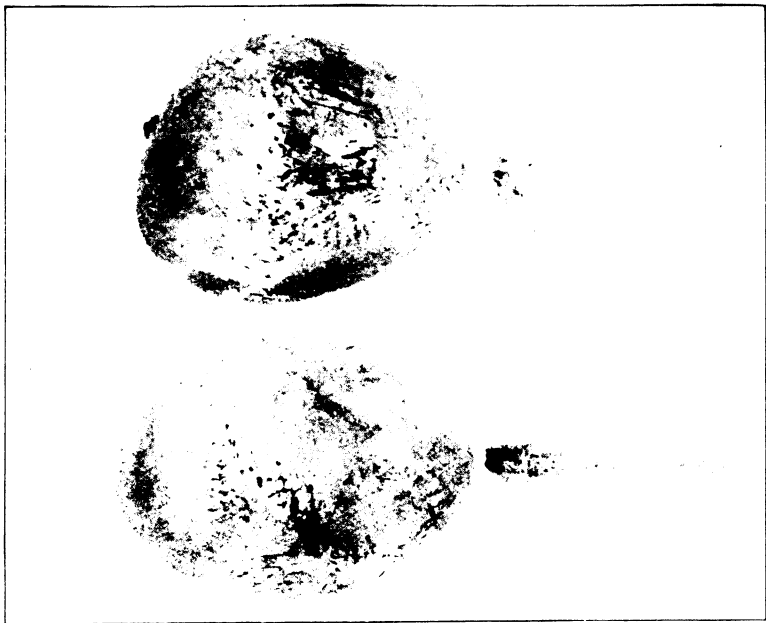
In addition to trials of these vegetables at the station, tests were made with most of them on a heavy loam soil a few kilometers north of Anasco. Some were planted also on the red spongy soil of the station's Mesa property.

Irish potatoes, broad beans, and peanuts have been growing since May 15 in the school garden at Maricao, which is 1,500 feet above sea level. The soil there is a clay that has been considerably lightened by heavy applications of manure. The Early Rose potato was the variety planted. On July 30 the condition of the crop indicated that it would be ready to dig within three weeks' or a month's time. The yield of three hills was one-half peck. The potatoes, of course, were not fully mature, but their shape was first-class, and they were free from disease and of splendid quality. The haulms were well grown and showed no signs of insect or disease injury. Peanuts, the seed of which was secured from Washington, D. C., were growing very well. Two varieties of broad beans from England were also promising. Seeds of the broad beans were harvested at the station last winter. The plant growth was very good, although late in the season the foliage showed signs of burning and the flowers blasted to some extent. It would seem, therefore, that the lowlands are too hot for this crop.

During the winter months the most successful vegetables grown at the station were tomatoes, cabbage, collard, eggplant, pepper, lettuce, squash, okra, Lima beans, beets, carrots, radishes, sweet potatoes, and peanuts.

Tomatoes.—Prolific and Sugar Cream, two California tomato hybrids, made very vigorous growth during the year. These plants were grown from seed produced in Porto Rico. Wilt, which was the most serious disease attacking the vegetables at the station, invariably cut the crop, because the plants died when the set of fruit was heaviest. Seed of five wilt-resistant varieties, Marvel, Norton, No. 324, Arlington, and Columbia, were secured from Washington, D. C., and the Ohio Experiment Station. These, together with Tomato No. 443, bred by the insular station at Rio Piedras, offer favorable opportunity for the production of an acclimated, resistant, and prolific variety for Porto Rican conditions. Trials at the station showed Tomato No. 443 to be a vigorous grower and a good producer. The fruit, however, lacks size and shape. It is by no means uniform. Pear-shaped types, smooth types, and much ridged kinds resembling the native fruit are all in evidence. This variety is the result of a cross between the Livingston Globe and the native cherry tomato. The vine growth of the latter has been strongly inherited.

During the year the station started a project having for its object the production of a vigorous growing, heavy yielding tomato which would bear large, smooth fruit. Insular Station Tomato No. 443 was used as the foundation stock. The seed was planted on April 26, 1920, and grew vigorously. On May 29 the plants were set in the field, and on June 30 they fruited. Cutting selections were made



FERNANDEZ MANGO (S. P. I. No. 19117).



CARICA PAPAYA, ONE YEAR FROM SEED (S. P. I. No. 46334).

from two of the best plants and bedded in sand on July 14. These were potted on July 29. Selections (by cuttings) from three other promising plants were made on July 29 and August 6. A few cuttings were also made of the Diener, a California tomato. These cuttings are to be grown to maturity in the greenhouse and crosses made from them. Tomato seedlings are also being raised. Plants will be grown from these seedlings by setting them in the field in late fall. Further crosses can be obtained when these plants mature. In this way the work will be continued.

On the Mesa, the Dwarf Champion tomato was much ahead of any others tested. In fact, this variety was the most successful of any tested during the past year. It was prolific and practically free from disease until very late in the season.

Cabbage and collard.—Cabbage and collard produced good crops during the past season as a result of having received much fertilizer and plenty of water. Early Jersey Wakefield did very well.

Eggplant.—The varieties of eggplants tested at the station this year were New York Improved, Black Beauty, and Florida High Bush. The plant growth of Florida High Bush was most desirable, though its fruit lacked size. The plant growth of the New York Improved and Black Beauty was so low that the fruit rested on the ground. All three varieties made good yields, both at the station and on the Mesa. The native eggplant is a very tall grower. It should, therefore, produce a good type if crossed with a variety having larger fruit.

Peppers.—Peppers grew very well at the station. Some selections were made from the most promising plants. Two hot varieties and three sweet ones were tried out.

Lettuce.—The greatest advance of the year in lettuce was the successful production of a heading type. This was the Mignonette, a small head lettuce having reddish tinged leaves. Very solid heads were formed, apparently because of rapid growth resulting from heavy fertilization. The loose-leaf types are grown widely over the island because they are easily produced.

Squash.—Squash was the best of the station's cucurbits. It was one of the three or four completely successful vegetables at Anasco, in spite of the fact that only commercial fertilizer was used on the ground where it was planted. Small summer squashes grew very well. Vegetable Marrow and Mammoth Chile were superior varieties. A native squash was also grown alongside for comparison. All varieties did well at the station.

Okra.—Okra was another of the best vegetables on trial at Anasco. The three varieties raised there were much better than any grown in the station garden. Dwarf Prolific and White Velvet did very well. The native okra, however, seems satisfactory for all purposes.

Lima beans.—The season was very favorable for Lima beans. The crop produced from American seed was a good one, owing to a dry spell that set in when it began to mature. The Fordhook Bush and Dreer's Bush bean were the best of their class. Small Lima beans such as Henderson's Bush did not thrive. The Leviathan pole bean grew very well and continued bearing until late in the spring.

Carrots and beets.—Carrots and beets were not successful at Anasco, but did very well at the station. All four varieties of carrots gave good yields, though French Forcing, Oxheart, and Danvers did better than Chantenay. Of the beets tested, Crosby's Egyptian was superior.

Radishes.—Radishes did exceptionally well at Anasco, and results from three crops at the station were all that could be desired. Radishes have been grown commercially in Porto Rico for many years. They are, perhaps, the easiest of all vegetables to produce here.

Sweet potatoes.—The horticulturist at the North Carolina experiment station sent this station tubers of seven of the most popular sweet potatoes in that State. Five of these grew well at the station, the variety Hayman being the most promising, judging from the quality, total yield, and shape of the tubers. Thirty-five varieties supplied by the Bureau of Plant Industry, United States Department of Agriculture, are now under test in the field.

Irish potatoes.—Of the two varieties of Irish potatoes, Cobbler and Bliss Triumph, the latter did best at the station. These potatoes were grown during the winter months and produced strong, disease-free tops. When dug, however, they were disappointing, only little more than the seed planted being returned. The Early Rose potatoes, planted at the station at the same time (May 15) as those at Maricao, were a complete failure.

Peanuts.—Two varieties of peanuts, Jumbo and Virginia Bush, did very well at the station. Tests of these varieties on the sandy soil of the beach were also successful.

Corn.—Sweet corn was tried at the station and on the Mesa farm. From a small planting at the latter place a dozen fairly good ears were secured. Worms finally destroyed the crop. Should another planting of sweet corn be made at the Mesa farm, measures will be taken to control the worms. A planting in the station garden was a failure, not a single ear of corn being picked. The early season was very dry, and conditions were strongly unfavorable for planting.

Cucumbers and muskmelons.—Rust killed cucumbers and muskmelons early in their growth. Aphids on the under leaves also hindered the growth of these plants. Watermelons grew well until the fruit crop began to draw heavily on the vines. The latter did not

have the strength to mature a crop. Two or three nearly mature melons were secured.

Kohl-rabi and onions.—Kohl-rabi was a success. Onions produced from seed, seedlings, and from sets yielded bulbs averaging 2 to 3 inches in diameter.

REPORT OF THE ENTOMOLOGIST.

By W. V. TOWER.

BEEES.

The past year was one of the hardest years that beekeepers in Porto Rico ever experienced. Reports from all parts of the island tell of severe droughts, and the small amount of honey stored. Honey brought a fair price, however, and should continue to pay well as long as sugar is high.

Records were kept of honey production (Pl. VI, fig. 1) and of the blossoming period of the various honey trees.

MOSQUITOES.

During the year a survey was made of the mosquitoes infesting Mayaguez. Mosquitoes were very troublesome at the station and throughout town. Eight species were found, including the malarial mosquito.

TICKS.

During the last six months of the year 1,500 cattle were dipped in the dipping tank at the station. Previous to this time no records were kept. Every three weeks the solution in the tanks is brought up to the standard either by adding chemicals to increase its strength, or by adding water to dilute it. Cattle owners are advised of this in order that they may promptly send in their animals for dipping.

Insectary work with ticks was continued. During the very dry winter months it was difficult to keep the various lots of ticks alive. Not much trouble was experienced in this regard during the rainy season. Studies were carried on with ticks taken from horses, dogs, and goats.

SCALE INSECTS.

For the past few years the purple scale in the citrus groves has been held in check by various beneficial fungi which prevail where windbreaks are employed. Very little spraying has been done in old orchards, though it has been practiced in new orchards.

The white scale increased the past season on account of the very dry spring and summer. This scale is worse in young groves planted

in light sandy soils than elsewhere. It has fewer species of beneficial fungi preying upon it than the purple scale, and it does not respond so readily to treatment.

The Florida scale has not been found in the groves for a number of seasons, though an occasional small infection has been observed at the station.

The rufous scale has been found a number of times in the groves and also on the fruit at the station during the past season. Should it become abundant, it may be brought under control by the use of the following formulas, which were found very effective in Florida:¹

Cold-stirred emulsion.

Fish-oil soap:			
By weight	-----	pounds	8
By measure	-----	gallon	1
Paraffin oil 24° or 28° Baumé	-----	gallons	2
Water	-----	gallon	1

Boiled emulsion.

Paraffin oil	-----	gallons	2
Water	-----	do	1
Fish-oil soap	-----	pounds	2
or			
Hard soap	-----	do	1

CITRUS SCAB.

In December, 1919, a grove at Palo Seco was platted and notes were carefully made showing the amount of scab present. This grove has always produced very scabby fruits, sometimes yielding as high as 90 per cent infected fruit. At the present time the grove is divided into four plats, each of which is receiving different fertilizers. Scab seems to follow heavy applications of nitrogen. A marked difference in the amount of scab is noted in certain parts of the grove. The south side, for instance, which did not get as much sun as the north side, showed a heavier infection of scab. Less scab was found where the production was the heaviest.

It would seem that an excessive application of nitrogen renders the tree susceptible to infection. If this is the case, it would be advisable to keep the trees in good condition throughout the year instead of giving them one heavy application of nitrogen just before blossoming time. It has been the practice of many growers to make

¹ Those especially interested in spraying for the control of insects may find valuable information by referring to Farmers' Bulletin 933, Spraying for the Control of Insects and Mites Attacking Citrus in Florida, which can be obtained by applying to the United States Department of Agriculture.



FIG. 1.—STATION APIARY.



FIG. 2.—KAVANGIRE, A JAPANESE CANE IMMUNE TO MOSAIC DISEASE;
10 MONTHS' GROWTH.

one application of fertilizer during the spring. This is done as soon after picking as possible, when the soil is in condition to plow. The plowing generally starts growth, and a heavy application of nitrogenous fertilizer produces a heavy, succulent growth. This fertilizer could be applied during the growing season, but it should not be used in hurtful quantities or at times when it would have any bad effect on the hanging fruit. Two or more small applications would, no doubt, be more advisable than one large application just at blossoming time.

WINDBREAKS FOR CITRUS.

The growing of windbreaks has been carried on for many years in Porto Rico, and the growers have profited by it. At present there is a tendency to plant more leguminous plants and trees for windbreaks. Among quick-growing kinds, the pigeon pea, *Agati grandiflora*, and *Crotalaria juncea* can be used as temporary windbreaks. The bamboo is being replaced by the bucare, guava, and guama trees for permanent windbreaks. It has frequently been noted that citrus trees become very thrifty and bear well when planted near the bucare tree. Too dense a shade from this tree tends to lessen production, though a reasonable amount of shade seems to be beneficial to the citrus. The planting of leguminous trees as windbreaks should be encouraged because they do not rob the trees as the bamboo does. Where bamboo is planted, the first and second rows of citrus trees often suffer and are never equal to the other rows because of the encroachment of the bamboo roots. The bamboo, however, is excellent in places where winds are very heavy because it bends without breaking.

MULCHING CITRUS.

Cane trash was applied as a mulch to a number of rows of trees in February, 1920. Other rows were left without treatment. The grove was taken care of in the usual manner, the centers being cultivated with a disc. In June most of the trees that had received a good mulch of cane trash showed a white bloom. Those without mulch were showing only a scattering bloom.

COVER CROPS FOR CITRUS.

Numerous plantings of sunn hemp (*Crotalaria juncea*) were made at the station (Pl. II, fig. 1), and those grown among the citrus trees were very promising. Strips of sunn hemp were planted in a grove on April 21, and two months later they were cut, their height then being 6 or 7 feet. The weight, including roots, per acre, is shown in Table 1.

TABLE 1.—*Calculated weight of sunn hemp per acre.*

Section of plant.	Green weight.	Air-dry weight.
	<i>Tons.</i>	<i>Tons.</i>
Stems, leaves, and roots.....	13.62	2.84
Stems and leaves.....	11.93	2.48
Roots.....	1.69	.36

The entire crop was thrown under the trees as a mulch. The leaves rotted in a very short time, and in about one month had disappeared, leaving only the soft, pithy stems.

On June 8, when the *Crotalaria* was about 3 or 4 feet high, part of a plat was topped at different heights, and later 2 to 6 branches developed from these plants. On August 5, 105 days from date of planting, these branches were cut and the green weights were taken. Table 2 gives the weights.

TABLE 2.—*Green weight of branches of Crotalaria topped at different heights.*

Number of plat.	Height when topped.	Yield per acre.	Height when cut.
		<i>Tons.</i>	<i>Feet.</i>
1	Check; not topped.....	29.62	
2	Topped at 12 inches.....	10.67	8½
3	Topped at 24 inches.....	22.49	9
4	Topped at 30 inches.....	23.95	9½
5	Topped at 42 inches.....	27.87	10½

This crop is new to the island and at present only two species of insects are found feeding on it. One of these is a small snout beetle which feeds on the young, tender pods. The other pest is the larvæ of a small butterfly that cuts small round holes in the pod, through which it enters and cuts the seed. The larvæ in the first stage are covered with hairs and are black and yellow, the black predominating. In the later stages the yellow predominates, and the long hairs disappear. A few of the larvæ were found completely enveloped in fungus. A number of seeds had been eaten, but the insects were destroyed before reaching full development. The fungus resembled that which works on the cane moth stalk-borer. The holes are generally near the top of the pod, where it is attached to the plant, and on the underside, where it is protected from the rain. The adult butterfly is very handsome, having pink wings with white circles and black dots in the centers. The head and thorax are white with black markings.

During a wet period snails ate the leaves on the stalks to a height of 5 feet. This was in a very thick planting where there was not much light.

INFLUENCE OF FERTILIZER ON QUALITY OF FRUIT.

On the Dreier farm certain plats in the grapefruit grove received different applications of nitrogen and potash. The nitrogen plats were dark green; those that had the same amount of nitrogen plus a large amount of potash were very yellow. The nitrate plat receiving no potash showed 45.9 per cent fancy fruit and 54.1 per cent ordinary fruit. The potash plat showed 75.3 per cent fancy fruit and 24.7 per cent ordinary fruit. Practically no difference was observed in size of fruit or in yield. The yield for the first picking averaged $7\frac{1}{2}$ packed boxes per tree, which is very high. Regarding holding qualities, the plat that received the potash had the smallest number of dropped fruits and the fruit seemed to be holding better. Reckoning on the high market prices of 1919, the potash plat would show a gain of 30 cents per box, or \$2.10 per tree, in favor of the potash. On the low market prices of this past year there was a difference of 12 cents per box, or 90 cents per tree.

SHADE FOR CITRUS TREES.

Observations were made during the year on two groves of citrus trees that have been growing under guava (*Inga vera*) shade. The fruits in the grove in the vicinity of Mayaguez were all borne singly and were very handsome, having kid-glove skin which was free from scab. The fruit on trees in the open was scabby and in clusters and far inferior to that in the shade. The same conditions were found in the other groves. The fruit on all trees growing in guava shade seems to be less in amount than on trees growing in the open.

REPORT OF THE SPECIALIST IN FARM MANAGEMENT.

By H. C. HENRICKSEN.

THE FRUIT INDUSTRY.

The general survey of the fruit industry, which was planned in 1917 and interrupted by the war, was again taken up this year. The work in connection with citrus fruits has been segregated into five projects with aims as follows: (1) To study the influence of soil, environment, and cultural treatment on stock and variety, measured by the size and health of the tree and the quality and quantity of the fruit it produces; (2) to determine the varieties that have become established in Porto Rico, as well as to select the most desirable types and to eliminate the undesirable ones; (3) to determine the

present cost of producing and handling fruit in Porto Rico, and to devise methods of reducing the cost; (4) to compare the fruit produced here with that produced elsewhere in regard to quality and quantity, method of packing, time of maturity, distribution and marketing, price received, and cost of production and handling; and (5) to obtain data on decay of fruit in transit, and to find methods of preventing this decay.

Projects 1 and 2 include work that will have to be carried on for several years before any definite results can be obtained. Much valuable information is being collected relative to all of these projects, and whatever is found to be of special interest is given out from time to time for use by the planters.

COST OF PRODUCTION.

It was found impossible to obtain accurate data on cost of production. The figures indicate that it is seldom less than \$1 per box for citrus fruit, and that it is very frequently as high as \$2 per box.

COST OF HANDLING.

The cost of handling fruit was studied in detail and data covering this work for the past 10 years have been tabulated. The packing-house costs vary according to the size of the house and the amount of fruit packed. Table 3 shows the average cost of handling fruit under the most favorable conditions. About 75 per cent of the fruit shipped from Porto Rico has not been packed under such conditions, however, and the cost has been from 25 to 40 per cent higher.

TABLE 3.—Average packing cost per box for plantation packing houses.

Kind of fruit.	Labor.	Boxes.	Paper.	Nails.	Straps.	Cleats.	Total.
	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>
Grapefruit:							
1910-1913.....	13	20.5	4.0	0.3	1.5	0.5	39.8
1914-1917.....	13	23.5	5.3	.6	2.0	1.0	45.4
1918-1919.....	13	36.5	7.0	.8	3.0	1.5	61.8
Oranges:							
1910-1913.....	15	20.5	6.0	.3	1.5	1.5	43.8
1914-1917.....	15	23.5	8.0	.6	2.0	1.0	50.1
1918-1919.....	15	36.5	13.5	.8	3.0	1.5	70.3
Pineapples:							
1910-1913.....	13	20.5	5.0	.4	1.5	.5	40.9
1914-1917.....	13	23.5	7.0	.9	2.0	1.0	47.4
1918-1919.....	13	36.5	9.0	1.5	3.0	1.5	64.5

The cost of labor has not been stationary, as would appear from Table 3. During the 10 years previous to July, 1919, wages for fruit plantations rose about 33 per cent for women and boys and 45

per cent for men. The increased efficiency of the laborers about offsets the rise in wages up to July, 1919, but it is questionable whether this is true to-day. The increased packing-house cost is due chiefly to the increased cost of materials, which amounted to about 60 per cent during the 10-year period.

Table 4 shows the total cost of handling a box of fruit from the time it is picked in Porto Rico until it is placed on sale in the auction room in New York. Very little of the fruit has been handled at a cost cheaper than that given in the table, and on at least 50 per cent of it the handling cost per box has been from 15 to 25 cents higher than the figures given. In 1919, for instance, it cost from \$1.40 to \$1.70 to pick a box of grapefruit and place it in the auction room in New York. The fruit is sold on a commission basis ranging from 6 per cent up, and therefore a box of fruit selling at auction for \$3 will be charged 18 cents or more commission. That, together with \$1.40, the minimum handling cost, deducted from the price, will leave \$1.42 to pay the production cost.

TABLE 4.—*Total handling cost of fruit per box.*

Kind of fruit.	Picking.	Packing-house cost.	Transportation to wharf.	Ocean freight.	Miscellaneous charges. ¹	Total handling charges.
	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>
Grapefruit:						
1910-1913.....	5.5	39.8	13	30	5.0	93.3
1914-1917.....	5.5	45.4	14	30	6.0	100.9
1918-1919.....	5.5	61.8	15	50	6.5	138.8
Oranges:						
1910-1913.....	7.0	43.8	13	30	5.0	98.8
1914-1917.....	7.0	50.1	14	30	6.0	107.1
1918-1919.....	7.0	70.3	15	50	6.5	148.8
Pineapples:						
1910-1913.....	7.0	40.9	13	35	5.0	100.9
1914-1917.....	7.0	47.4	14	35	6.0	109.4
1918-1919.....	7.0	64.5	15	55	6.5	148.0

¹ Miscellaneous costs include dock inspection, marine insurance, and cartage and labor in connection with auction samples.

SOME OF THE FACTORS INFLUENCING PRICE.

A great many statistical data comparing fruit production in Porto Rico and other countries have been gathered locally, but comparative figures are still wanting from countries with which Porto Rico must compete.

Table 5, based upon figures obtained from the Porto Rico Fruit Exchange, illustrates the influence of time and shipment upon the price of the fruit.

TABLE 5.—Average percentage of fruit shipped monthly from Porto Rico and the average price and returns after the handling cost has been deducted.

GRAPEFRUIT.

Month.	July, 1910, to June, 1914.			July, 1914, to June, 1917.		
	Proportional shipment per month.	Average monthly selling price in New York.	Returns after deducting handling cost.	Proportional shipment per month.	Average monthly selling price in New York.	Returns after deducting handling cost.
	Per cent.			Per cent.		
July.....		\$2.93	\$1.82		\$1.96	\$0.83
August.....		5.21	3.97		2.60	1.43
September.....	2.1	4.53	3.33	2.6	3.16	1.96
October.....	5.5	3.71	2.56	12.2	2.95	1.76
November.....	8.1	2.53	1.45	19.0	2.07	.93
December.....	9.5	2.35	1.27	13.0	1.48	.38
January.....	15.9	2.79	1.69	11.0	1.79	.67
February.....	21.6	2.24	1.17	16.0	1.58	.47
March.....	18.4	2.50	1.42	13.5	2.04	.90
April.....	13.7	2.19	1.13	8.8	2.39	1.22
May.....	4.7	2.88	1.78	1.8	1.76	.64
June.....	1.5	3.30	2.17	1.0	2.04	.90
Average annually.....		2.61	1.52		2.05	.91

ORANGES.

July.....						
August.....		\$1.54	\$0.46		\$1.43	\$0.27
September.....		2.45	1.32	0.3	1.34	.19
October.....	3.5	2.25	1.13	4.0	2.04	.85
November.....	11.3	1.55	.47	23.4	1.66	.49
December.....	16.5	1.41	.34	24.2	1.38	.23
January.....	22.6	1.35	.28	17.8	1.63	.46
February.....	20.4	1.57	.49	13.0	2.05	.86
March.....	14.2	1.96	.86	12.6	2.08	.89
April.....	7.8	1.69	.60	4.2	2.17	.97
May.....	1.4	2.19	1.07	1.7	1.73	.56
June.....	1.5	2.42	1.29	.8	1.38	.23
Average annually.....		1.51	.43		1.78	.60

PINEAPPLES.

July.....	6.0	\$5.28	\$3.96	5.1	\$1.82	\$0.62
August.....	2.5	1.88	.76	3.0	1.81	.61
September.....	1.5	2.13	1.00	2.1	2.01	.88
October.....	1.4	2.28	1.14	1.3	2.22	1.00
November.....	2.3	1.89	.77	3.2	2.23	1.01
December.....	2.7	1.76	.64	5.2	1.53	.35
January.....	2.5	1.98	.85	2.8	2.03	.82
February.....	1.7	2.32	1.17	1.9	2.84	1.58
March.....	5.3	3.06	1.87	3.8	3.02	1.75
April.....	21.7	2.29	1.14	17.5	2.50	1.26
May.....	37.3	1.71	.60	36.9	1.78	.58
June.....	14.5	1.87	.76	16.1	1.70	.51
Average annually.....		1.97	.84		2.01	.80

Data are shown for two periods—July, 1910, to June, 1914, and July, 1914, to June, 1917—because of the differences in handling cost as well as in selling price during these periods. Figures were compiled for three periods, but inasmuch as the data for the last period are not complete at this time no statement can be made concerning them. Regarding time of shipment, the months of July and August need not be considered in the case of the citrus fruit because less

than 1 per cent of the total fruit is shipped during these two months. The price of grapefruit is always high during the months of September and October, but only a comparatively small quantity is mature enough for shipment then. The quantity of oranges maturing before November is still smaller, but the October price is as a rule higher than that of any month later. After November 15 the price of oranges and grapefruit fluctuates according to the quantity reaching the market from elsewhere. The bulk of the fruit is shipped between November 15 and April 15. The market is too frequently glutted at this time, because the bulk of the Florida and Cuban fruit is also shipped then. The condition is reversed in the case of pineapples. The months of February to April, inclusive, are the most profitable for shipping this fruit. However, the quantity maturing then is small. For many years the bulk of the fruit was shipped between May 15 and the first week in June, and a sharp break in prices always occurred between May 15 and 20. During the last three years the crop has been short, and conditions in prices have changed. Under the heading "Returns after deducting handling cost" in the table is shown the average amount of money per box left over after the handling cost has been paid and the 6 per cent commission for selling has been deducted.

The annual shipments of citrus fruit and pineapples during the past 11 years are shown in Table 6.

TABLE 6.—*Annual shipments of fruit from Porto Rico since 1910.*¹

Year ending June 30.	Grapefruit.		Oranges.		Pineapples.	
	Number of boxes.	Value.	Number of boxes.	Value.	Number of boxes.	Value.
1910.....	48,441	\$162,749	296,058	\$582,716	277,058	\$555,044
1911.....	96,189	309,698	349,442	703,969	335,641	641,291
1912.....	118,937	525,048	277,422	584,414	319,096	684,774
1913.....	216,247	726,811	353,690	740,091	360,288	1,142,348
1914.....	206,200	751,769	348,927	752,180	369,952	1,246,001
1915.....	276,583	834,440	200,311	378,181	552,085	1,723,863
1916.....	296,645	837,014	404,451	790,797	532,259	1,176,406
1917.....	435,890	939,677	503,318	1,009,737	416,550	916,415
1918.....	549,125	1,120,330	603,226	1,231,551	145,605	617,496
1919.....	417,369	739,106	373,679	770,303	116,000	458,675
1920.....	419,629	1,332,742	336,625	833,575	140,906	479,461

¹ The figures were taken from the customhouse records, and the values are therefore according to shipping declarations and not according to the actual price received.

Most of the citrus fruit is packed under five grades. Some houses pack under four grades, but most houses employ an extra grade when occasion demands.

Table 7 shows how the prices of the five grades compare with one another; it also shows the percentage of each grade shipped, and the net return after all the handling costs are paid at the rate of \$1.50 per box, plus the commission of 6 per cent for selling.

TABLE 7.—*Prices as influenced by grades at the Porto Rico Fruit Exchange during the season of 1918-19.*

Kind of grapefruit.	Proportional shipment of boxes from Porto Rico.	Average price received per box.	Handling cost per box. ¹	Returns after deducting handling cost.
	<i>Per cent.</i>			
Blue Ray	1.75	\$5.36	\$1.82	\$3.54
Red Ray	19.36	4.37	1.76	2.61
Purple Ray	41.00	3.83	1.73	2.10
Bronze Ray	12.42	4.20	1.75	2.45
Sunniace	25.45	2.89	1.67	1.22

¹ In handling cost the average figure of \$1.50 per box has been used as a basis, plus the commission of 6 per cent for selling.

It is readily apparent from Table 7 that the high prices received for grapefruit in 1918 to 1919 would not only pay the cost of production, but also leave a safe margin for profit. Unfortunately, however, conditions are not always so favorable. The principal difficulty lies in the shipment of a large percentage of low-grade fruit. This difficulty is being overcome by using the low-grade fruit for marmalade and its juice for bottling as a beverage. The highest grade of fruit amounts to less than 2 per cent of the total grapefruit shipped, as shown by the figures in Table 7. This is a difficulty that has yet to be overcome. The problem to be solved is to find a means by which some of the fruit in the lower grades can be raised to that of the next higher grade. It will be observed that the difference in price between any two adjoining grades ranges from 93 cents to \$1.44, and a grower can well afford to spend 50 cents or more per box to raise a lower grade of fruit to a higher one.

Grapefruit is packed in 10 sizes, ranging from 28 to 150 in a box. The two extreme sizes usually amount to less than 0.5 per cent each of the total shipment and the price is seldom satisfactory. There is sometimes a fair demand for the 28's and 36's during the early part of the season, though they may be unprofitable later. The five sizes 46 to 96 are the most profitable, and about 90 per cent of the total ranges between these extremes, varying of course from year to year.

Pineapples are packed in 10 sizes ranging from 16 to 64 in a box. Nowadays only a very small percentage reach a size larger than 24. In 1918 about 10 per cent of all the fruit was packed as 54's and 64's, but the price on these sizes is frequently too low to be profitable. In pineapple growing the problems are how to produce large fruit, how to produce enough slips to maintain the fields, and how to maintain the land in a condition to produce profitable crops. These problems are being studied, but no report can be made concerning them at this time.

FRUIT ROT.

A study of decay in transit and its prevention was started in response to a request from the fruit growers. As a beginning, all available data were tabulated; the amount of decay was shown as reported by the receivers in New York, the individual grower, the house in which the fruit was packed, the boat on which it was shipped, and the time of the year shipment was made. The tabulations made reveal the following main facts: The decay in grapefruit ranges from practically nil with some growers up to 15 per cent in shipments from other plantations. Oranges show considerable decay, regardless of where they are grown; seldom less than 5 per cent, usually 10 to 15 per cent, and frequently 25 to 50 per cent. The decay of pineapples ranges from nil to 10 per cent. The fruit from several plantations shows no decay; from a great many others the decay is less than 5 per cent. Occasionally, however, the figures are as high as 20 or 30 per cent. This great variation in decay of fruit from the different plantations has made it impossible to determine the influence of handling in the packing house. Moreover, it is not safe to draw conclusions from the results of one boat over another. It is true that personal observations greatly aid in making the figures much clearer, and for this reason an effort is being made to keep personally in touch with all phases of the problem. The information at hand now, although not complete, has already been of great help to individual growers.

While the decay of grapefruit and pineapples is relatively not large, the actual loss caused by it is considerable. The loss due to decay of fruit, excluding the oranges, is more than \$100,000 annually. The loss from decay in oranges can not be calculated from the data at hand. Approximately, three-fourths of the oranges shipped from Porto Rico are the so-called wild fruit. No data have been collected on these, but the loss on them is always very great. For this reason \$100,000 will perhaps be a low estimate for oranges.

The loss of the fruit itself and the very high repacking charges are small matters compared with the actual loss in money due to all of the fruits selling at a lower price on account of the decay. That loss can not even be estimated, but all those who handle Porto Rico fruit state that fruit rot is the greatest factor in the selling problem.

The problem of how to eliminate or lessen the decay in fruit must be attacked in the field, in the packing house, and at the different stages of shipping and storing. The shipping problem was the first attacked in this investigation, and it resolved itself into two factors—the effect of ventilation and the effect of temperature.

TEMPERATURE READINGS.

Weekly temperature readings were taken on the wharves in San Juan of the air and of the packed fruit awaiting shipment. Table 8 is a representative sample of these readings. The observations show that the air temperature of the wharves is very close to the average maximum temperature of the air in San Juan; also, that the temperature in the center of a packed box of fruit is several degrees lower than that of the air, even after the fruit has been on the wharf one or two days.

TABLE 8.—*Temperature on the wharf in San Juan in 1919.*

Month.	Air on wharf.	Air in center of packed box.	Month.	Air on wharf.	Air in center of packed box.
	°F.	°F.		°F.	°F.
September.....	85	82	December.....	81	77
October.....	88	83	January.....	80	76
November.....	80	75			

The officers of some of the fruit-carrying steamers were induced to fill in specially prepared blanks three times a day during each voyage. These blanks recorded the barometer readings, and the temperature of the air and water, as well as of the holds in which the fruit was stowed. The record also included the amount and kind of ventilation provided for the fruit, the cargo other than fruit carried in each hold, and the state of the weather throughout the voyage.

A summary of all the reports received shows the following facts, which are of special importance for the purposes of this investigation. The temperature of the air during the first two days out from San Juan ranges roughly from 82° to 75° F., according to the time of the year and the time of the day. On the third day out it is seldom much below 70°, except in the coldest months. During the rest of the voyage, 1½ to 3 days, the air temperature is governed by the time of the year.

During the first three days out from San Juan the temperature of the water shows so little difference from that of the air that it can exert no perceptible difference on the temperature of the holds below the water line. During this time the temperature of the holds may be kept nearly the same as the temperature of the air with natural ventilation, provided the weather is calm enough to allow for ventilation. The ships on which the records were kept were not fitted with artificial ventilation. The term "hold," as used here, means any free space in the hold.

The assumption that certain cargoes, such as sugar, develop more heat than certain other cargoes was not verified by the data collected.

Self-registering hygro-thermographs were kindly furnished by the Bureau of Plant Industry, United States Department of Agriculture, but it was not possible to make use of them on the ships; neither was it possible to study the effect on the fruit of the gases evolved in the holds. These problems are now under investigation.

INFLUENCE OF TEMPERATURE ON PACKED FRUIT.

Through the cooperation of an ice company, 24 boxes of grapefruit and oranges were placed in a room having a constant temperature of from 54° to 56° F. A small percentage of the fruit developed decay, and the experiment was discontinued. Facilities were next provided by a brewing company in a room having a temperature of about 40° F. For nearly two months self-registering hydro-thermographs were kept in this room showing a temperature of 35° to 40° F., and a relative humidity of 90, ranging from 85° to saturation. One or two dozen boxes of fruit were placed in the room from time to time and left there for from 1 to 8 weeks. As a result not a single fruit decayed that was not physically injured.

Among the many notes obtained the following are of especial importance: The time in which the center of a packed box of fruit cools down depends upon the closeness of the pack. Grapefruit cools more quickly than oranges, and unwrapped fruit cools more quickly than wrapped fruit. The same rule applies for heating up after the fruit has been cooled. Where the air temperature was 80°, a packed box of fruit showed an increase of 5° or 8° in temperature within the first hour after it was removed from the cool room. The temperature was taken in the center of the box. After the first hour the rise in temperature was more gradual. When the fruit was removed from the cool room the condensation was always very great. The tissue wraps became entirely soaked within a few hours, causing a mussy condition in the pack. Fruit which was kept in the cool room for 2 to 6 weeks and then removed to air temperature did not decay any sooner than fruit that was recently picked, provided the wet wraps were removed. Fruit which was physically injured—that is, having the peel bruised or scratched—did not break down in the cool room during a stay of 2 months; however, it did break down rapidly after it was removed into the air temperature. Perfectly sound fruit, when packed with fruit that had started to decay, did not become contaminated while in the cool room; that is, such fruit, when unpacked and dried, kept as well as fruit recently picked. Fruit in the first stage of decay, showing symptoms of stem-end rot, did not break down to the stage of leaking even when it was placed in the cool room for 6 or 8 weeks. The fruit which was kept in the cool room from 4 to 6 weeks or more showed more or less so-called scald spots.

These spots appear as brown, sunken areas in the peels. They do not impair the quality of the fruit but greatly reduce the selling value. The scald spots did not develop, however, on fruit which was kept in the cool room for one week only. In studying this problem it was found that wrapped fruit developed scald spot as well as fruit without wraps. Fruit that was purposely bruised and immediately coated with paraffin also developed brown spots. The spots developed only where the peel had been injured. Any bruise or spot turned brown; anthracnose spots especially were greatly aggravated. During the first two days the fruit was out of the cool room the spots were inconspicuous, but they showed up fully the third day, and more so the fourth and fifth days.

INFLUENCE OF PARAFFIN AND SHELLAC ON PACKED FRUIT.

The investigation of the influence of paraffin and shellac on packed fruit was suggested by F. S. Earle, of the Insular Experiment Station at Rio Piedras. Several lots of fruit were treated in the following manner:

The stem with the adhering calyx was pulled out, the stem cavity was sealed up with shellac in alcohol, and the entire fruit was then rubbed over with paraffin. No conclusive results were obtained with grapefruit, because the boxes that were under observation in Porto Rico did not show a perceptible amount of decay; the reports on the lots sent to New York were very much mixed. The results with oranges were conclusively negative, that is to say, the treatment did not prevent stem-end rot. For instance, one lot that was treated and kept for 10 days showed a decay of 8 to 16 per cent due to stem-end rot. Only one fruit showed blue mold out of 10 boxes. The check lot ran slightly below in stem-end rot, but several fruits showed blue mold. Blue mold, however, was not very troublesome at any time during the year.

The paraffin showed interesting possibilities as a protection against contamination and shriveling. Whether paraffin may be substituted for tissue wraps is a matter well worth considering. The tissue wraps are unquestionably of some value as a protection against the spread of blue mold, but they afford very little protection against contamination from a leaky fruit infected with stem-end rot. These points were brought out very clearly in inoculation tests. Sound grapefruit wrapped with a small piece of decayed fruit and laid on the stem end did not readily become infected; rather, the piece of decayed fruit seemed to dry up. A decaying whole fruit when packed always had the expected effect. Its juice leaked onto the adjoining fruit and soon contaminated half a box, although the fruit was wrapped in the usual manner. A piece of decayed fruit placed in a box of oranges usually produced contamination.

ORGANIZATION WORK AMONG THE FRUIT GROWERS.

Since the establishment of the office in San Juan, an effort has been made to organize the fruit growers, among other things, to carry out all investigations on a cooperative basis; to enable each one to derive immediate benefit from the solution of any problem; and to stimulate an interest in, and adoption of, progressive methods that have stood practical test. This effort has finally been crowned with success. As a result of several meetings held during the year, a Fruit Growers' Executive Committee has been appointed, representing the entire fruit interest of the island.

AGRICULTURAL EXTENSION NOTES.

The San Juan office prepares timely information on agriculture and issues it in mimeographed form. Each month an issue containing probably 1,000 words is sent out, 500 copies being in the English language and 12,000 in Spanish. In addition to miscellaneous matter, 24 important subjects were treated during the year. These publications are known as the "Agricultural Extension Notes," and can be had free of charge upon application.

MISCELLANEOUS WORK AT THE SAN JUAN OFFICE.

In addition to the work outlined above, the office keeps in touch with the special teachers of agriculture in the department of education as well as the Agricultural League. The constant effort is to collect reliable data on yields and cost of production of all crops in all localities. This information is of the utmost importance, but, unfortunately, it is very hard to get. The effort made so far has resulted in very little tangible evidence, but it has helped to open the way for future work.

REPORT OF THE AGRICULTURAL TECHNOLOGIST.

By W. A. MACE.

Investigational work was continued at the station with rice, cowpeas, soy beans, and the mung bean. Some experiments were begun with cotton. Plantings of cowpeas and soy beans were absolute failures this year. It was impossible to get a stand with these crops, owing to the extensive drought which prevailed throughout the spring. Several plantings were made, but each time the results were exceedingly poor.

The station distributed elephant or Napier grass (*Pennisetum purpureum*) as in other years, and reports from all parts of the

island show that plantings of this grass are giving encouraging results. Requests for cuttings and cultural directions continue to be numerous. During the past spring the station distributed about 500 pounds of seed of the mung bean to the farmers of the island. Distribution was made through the Agricultural League, agricultural teachers, and municipal officials to the small farmers and planters of such food crops as rice, beans, corn, and the like. The station has listed, from all parts of the island, the names of over 1,000 farmers who received the seed of the mung bean. It is early yet to expect reports on this seed, but it is hoped that the bean will do well because it is a much surer crop than any of the commoner varieties of beans.

Owing to lack of water for irrigation, nursery planting of rices received from the Office of Cereal Investigations, United States Department of Agriculture, was made in August of last year instead of in the early spring. The greater number of these rices suffered much from lack of water to mature the crop. The dry season set in early this year, coming on just about the time that the panicles were emerging in the rices. It was impossible therefore to mature the crop. This year the planting of the nursery to these rices was made early in the spring. A poor stand was obtained on account of the very dry season.

The samples of native rices which were collected last year were grown this year at the station. Data regarding them are interesting and valuable. When the 145 samples were classified it was found that they contained only 17 varieties of rice. In some of these varieties various strains were found. A few of them promise to be very prolific producers. It is probable that after selections are made for a few generations a very valuable strain can be obtained for planting on the hillsides throughout the island. Quite a number of samples when grown and classified were found to be wild rices. Of these there were four or five types. These, together with several other varieties found in the collection, are interesting only inasmuch as they furnish data or a reason for studying the plant. It is likely that they will be discarded. Further plantings have been made of the most promising varieties for continuing investigations.

The cooperative plantings made with the planters on the island during the past season were not very encouraging. It was impossible to keep the land submerged in these plantings, and the data desired concerning them could not be obtained. Some of the plantings gave fair yields, however, considering the adverse conditions under which they were grown. Two plantings were made in late summer with the idea of growing rice on land that is to be used for spring planting of cane. These gave fairly good results.

Some work has been carried on with small planters to help them in improving the rice industry on the island. This work consisted principally in introducing certain varieties of rice that are known to be superior to the native rice. This work is being continued and its results so far are exceedingly good.

During the year the station planted a number of grasses that were furnished by the Office of Forage-Crop Investigations, United States Department of Agriculture. Among these were Guatemala grass (*Tripsacum laevis*), Kikuyu grass (*Pennisetum longistylum*), the Merker grass (*P. merkeri*), and Cayenne grass (*Echinochloa polystachya*). All of these started out well, but none seems to do as well as the Napier grass. The Kikuyu grass was lost in cultivation. Some canes of the Cayenne grass grew to a length of about 13 feet and then succumbed to the dry weather. The Merker grass did well. It resembles Napier grass very much. Its canes are finer, however, and it does not produce as great a quantity of fodder as Napier grass. The Guatemala grass grew well through the dry season. It is a very slow grower, but it kept a beautiful green color throughout the extensive drought of last spring and summer.



OCT 25 1922

**PORTO RICO AGRICULTURAL EXPERIMENT STATION,
MAYAGUEZ, P. R.
D. W. MAY, Agronomist in Charge.**

Under the supervision of the STATES RELATIONS SERVICE,
Office of Experiment Stations, U. S. Department of Agriculture.

**REPORT OF THE PORTO RICO
AGRICULTURAL EXPERIMENT
STATION.**

1921.



Issued September, 1922.



**WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1922.**

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PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of the States Relations Service, United States Department of Agriculture.]

A. C. TRUE, *Director.*

E. W. ALLEN, *Chief, Office of Experiment Stations.*

WALTER H. EVANS, *Chief, Division of Insular Stations,*
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LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., October 25, 1921.

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Porto Rico Agricultural Experiment Station, 1921.

Respectfully,

D. W. MAY,
Agronomist in Charge.

Dr. A. C. TRUE,
Director, States Relations Service,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.

A. C. TRUE, *Director.*

Publication authorized.

HENRY C. WALLACE,
Secretary of Agriculture

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REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1921.

REPORT OF THE AGRONOMIST IN CHARGE.

By D. W. MAY.

INTRODUCTION.

During the fiscal year 1921 agricultural production in Porto Rico showed a phenomenal increase, the money value of which has seldom been equaled on another area of the same size in so short a time. The annual exports of the island have steadily grown from around \$8,000,000 in 1901 to \$151,000,000 in 1921—a figure which is so extraordinary as to seem almost incredible. Porto Rico has a population of 377.8 per square mile, and it is now one of the most densely inhabited regions of the world. The island has no large cities which are supported by manufacture and its people are largely dependent upon agriculture for a livelihood. The future of Porto Rico is contingent upon the energy of its people, but the island should continue to flourish, since it is at the gate of the best markets of the large eastern cities of the States, has a low freight rate, and is free from duty.

SUGAR.

While general conditions regarding crop production were good during the year, all lines of agriculture were somewhat affected by the fall of prices from abnormal levels. Sugar fell from 24 to 4 cents a pound within the short space of 12 months. Unfortunately, very little attention was given to the production of other crops during the period when sugar was bringing high prices, and cane plantings were extended to lands that do not produce sugar at a profit in normal times. The cost of labor and materials increased with the price of sugar, and while the increase in wage undoubtedly did benefit the laboring classes it resulted in heavy losses for the plantation owners, the majority of whom had to face the problem of harvesting the crop at a value below the cost of production when the price of sugar fell.

As a result of the decline in price, it is likely that the plantation owners will begin to develop the other agricultural industries of the island. The station has repeatedly emphasized the necessity of diversifying agriculture in Porto Rico and with this purpose in view

has introduced and promoted the production of many new and promising crops. It is only by continued losses, however, that the planters can be made to realize the necessity of practicing a rotation which will result in the production of many foodstuffs for a number of years instead of growing a single remunerative product for the present.

As an outcome of the change in economic conditions, many of the lands that are not well adapted to cane will go back to pasture, with a resultant increase in the production of live stock, and the difficulty of feeding the ever-increasing population doubtless will be considerably lessened by the growing of crops which will constitute a balanced diet for human beings. A forced rotation is better than none at all, and it should prevent the loss which annually occurs wherever land is kept continuously in cane cultivation.

To safeguard the sugar industry, it is suggested that Porto Rican farmers continue to seek high-yielding varieties of cane that are immune to disease, plant legumes that will lessen the cost of fertilizers, practice a system of rotation, and use better methods of cultivation and up-to-date machinery to keep down the growing cost of labor.

During the year it was noted that cultural methods in cane production continued to improve, with better preparation of the land and the cultivation of the growing crop and that costs were materially reduced on plantations where up-to-date machinery had been installed. The mottling, or mosaic, disease of cane was less threatening this year than in former years. The control was partly due to the disease having run its course and partly to the elimination of diseased canes and the growing of immune or apparently immune varieties of cane.

At the station the major experimental work was confined to the breeding of new varieties of cane, demonstrating the value of cultivators, especially of the disk type, and the rotating of canes with legumes.

ANIMAL INDUSTRY.

Cattle.—The cattle generally found in Porto Rico are doubtless descendants of some that were brought from Spain in the early days following the discovery of the island. Until within the last few years no attempt was made to improve these cattle either by the importation of new breeds or by the judicious selection of the native cattle. Yet, notwithstanding these facts, the native cattle of Porto Rico are a strong race of good conformation, and make excellent work animals.

An earnest effort is now being made in Porto Rico to improve the cattle of the island, and the introduction of purebred animals from

the North will doubtless continue to increase as the cattle tick (*Margaronus annulatus*) is brought under control. The station does not recommend the importation of purebred stock by the general stock farmer until greater progress has been made in eliminating the cattle tick, or at least until the farmer is prepared to give introduced cattle good stabling, feed, and grooming.

A decrease in cane growing in Porto Rico will result in an increase in live-stock production. As one industry declines the other advances. Cattle are the main motive power used in cane growing. They are used to break the ground, to cultivate the cane, and to haul it from the field. When the cultivation of cane fields ceases the lands go back to pasture and are then employed in the raising of cattle.

The introduction by the station of certain forage crops has given a great impetus to cattle raising. Animals can not be expected to yield a profit unless they are given plenty of nutritious food. In raising cattle one should remember to breed for quality and to feed for quantity. Since the common grasses, and even the cultivated grasses, do not contain sufficient nourishment for stock, they should be supplemented with leguminous plants or grains having a high protein content. The station has found the velvet bean and the *Crotalaria* to make excellent feeds for cattle and valuable green-manure crops for the soil. Napier or elephant grass (*Pennisetum purpureum*) (Pl. I, Fig. 1) is so far the best of the introduced grasses for live stock. Guatemala grass (*Tripsacum dactyloides*) does very well on dry land (Pl. I, Fig. 2). A pasture grass (*Polytrias premorsa*) from Java has been found promising not only for grazing purposes but also for ornamental purposes. It is a low creeping grass and has a better color than have the native grasses.

Dairying.—The output of milk per native cow is low. In a study made by the station to ascertain the quantity of milk yearly given by the native cow, it was found that 324 head averaged 6.47 pounds per day per cow. During the eight months the records were kept the average yield per cow was 1,552.8 pounds, or at the rate of 2,329.2 pounds per annum.

The station keeps two purebred Guernsey bulls of good stock for the herd, which was started some years ago with native cows. The animals now milked are three-fourths to seven-eighths purebred. The influence of the station bulls is shown in the improved quality of the dairy cows in the community. The improvement of yields in the station cows by crossbreeding is very noticeable. In the station herd, the native cows yielded an average of 8.09 pounds of milk per day, the half-bred cows (Pl. II, Fig. 1) 11.9 pounds, and the three-quarters-bred cows (Pl. II, Fig. 2) 13.5 pounds. This shows an increase of 47 per cent for the half-breeds over the native, and 13½ per cent gain for the three-quarters-bred over the half-bred.

It was noted during the year that methods of dairying were improving throughout the island. The improved methods are deserving of careful consideration, because upon them depends the quantity of milk delivered at each milking and the maintenance and uniformity of the milk flow.

Horses.—In Porto Rico little interest is taken in horse breeding. In the smaller towns horses are used to draw carriages and coaches and in the country districts they are saddle bred. The horse has never been used to any extent in Porto Rico as a draft animal, being replaced in this regard by cattle, and for transportation purposes by the automobile.

Swine.—Pigs are raised in small lots on the plantations and usually singly by the laborers. These animals are largely employed as scavengers and can not be improved or raised in greater numbers until a larger amount of feeds is produced for their maintenance.

Goats.—Some improvement is being brought about with goats, "the poor man's cow," by the introduction of better sires and by careful selection in breeding. There is room for improvement in this line of live-stock production in Porto Rico. The goat is adapted to the use of families who find it impossible to keep a cow because of limited space or an insufficient supply of food for the larger animals.

A goat will lower the cost and enlarge the supply of milk for the small farmer. One good milker will furnish an average family with a fine quality of milk for the greater part of the year. Three quarts a day is thought to be indicative of a good animal. Six or eight does can be kept on the amount of feed that is required for one cow. The marks and conformation which distinguish a good cow also appear in a good goat.

Poultry.—The Game is a breed which still predominates in Porto Rico. There is, however, a growing interest in the utility breeds, and many new fowls are being annually imported into the island. Of the introduced breeds, the Leghorns and the Plymouth Rocks are found in the greatest numbers. The production of chickens should be more general than is now the case. The number of domestic fowls in Porto Rico is very small when one considers the place that eggs and poultry should occupy in the diet of the million and a quarter people on the island. Notwithstanding the fact that poultry products bring relatively high prices in Porto Rico throughout the year, the farmers do not produce enough of them to supply the local demand, and refrigerated poultry is continually being brought in from the States for food, and eggs for breeding purposes. The small eggs of the native hen are usually higher in price by weight and even sometimes by the dozen than are the eggs which are imported from the North.

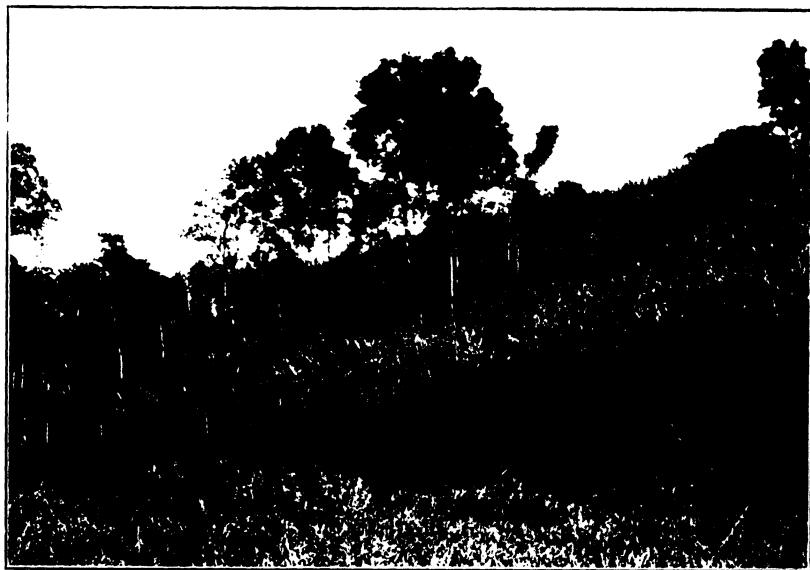


FIG. 1.—ELEPHANT OR NAPIER GRASS GROWING ON CUT-OVER LAND.



FIG. 2.—GUATEMALA GRASS AT STATION.



FIG. 1.—STATION COW, ONE-HALF GUERNSEY, ONE-HALF NATIVE.



FIG. 2.—STATION COW, THREE-FOURTHS GUERNSEY, ONE-FOURTH NATIVE.

In the rural districts there is enough feed growing around the small homes to support at least a few hens, and additional feeding crops can be grown if needed at almost any season of the year. Nevertheless many of the small farmers and a large number of the farm laborers do not own domestic fowls of any kind. The only way to remedy this state of affairs is to give constant and unremitting instruction on poultry in the rural schools and by agricultural agents.¹

Advice with reference to animal production.—The station will be glad to assist the farmer to solve the many problems which daily confront him in connection with the care, feeding, and breeding of stock. The farmer should clearly state the kind of stock to be fed, the place whence the feed is obtained, and the price paid for it. Home-grown feeds should be given the preference over imported feeds. The station will gladly outline a feeding plan to suit each case, and state the amounts and proper mixtures to be fed, so that the best results may be obtained at the lowest cost. The rations should be made attractive and palatable to the animal. Information regarding the care and breeding of animals can be had upon application to the station.

REFORESTING.

The station has continued in its efforts to impress upon the local public the necessity of protecting and developing the insular forests, and it has encouraged the growing of choice varieties of fruit-bearing trees, and especially those having a high food value. Improved varieties of guavas were propagated and widely distributed during the year. Thousands of ornamentals also were sent to all sections of the island. Plantings, especially of cabinet woods, were again made on the Mesa, above Mayaguez. (Pl. III, Fig. 1.) Among the introduced fruits on this mountain was the avocado, which seems to do better at this location than on the lowlands of the station. *Spathodia campanulata*, which is a handsome tree and makes quick growth, is being recommended for street planting.

DISTRIBUTION OF SEEDS AND PLANTS TO STATE STATIONS.

During the year some promising tropical plants were sent to the experiment stations of the Southern States, and seed of *Crotalaria juncea* was sent to the stations south of the Ohio River and along the Pacific coast, with the recommendation that the latter plantings be used as a cover crop. The *Crotalaria* makes such a quick growth, flowering in two months and ripening in three, that it apparently would do well in a small-grain rotation in the North if it were sown

¹ During the year the station issued a circular on poultry keeping in Porto Rico (Porto Rico Sta. Circ. 19), copies of which may be had by addressing the agronomist in charge.

after wheat, oats, or rye has been harvested. Very favorable reports concerning it have been received from several of the State stations.

HOW THE STATION REACHES THE PEOPLE OF PORTO RICO.

The station keeps in touch with the people in all parts of Porto Rico (1) by means of its publications, (2) by Agricultural Extension Notes which are mimeographed on the island, (3) by having members of the staff visit the various sections of the island, (4) by having those of the people who can do so visit the station, and (5) by correspondence.

The publications, which are printed at Washington, are regularly distributed to those whose names appear on the station's mailing list and will be sent to anyone else who is interested in the work of the station. These publications include annual reports, which keep the people advised regarding the progress of work from year to year, and bulletins and circulars which deal in detail with some particular feature of the work of the station. All of these publications are issued free of charge.²

Agricultural Extension Notes contains from 800 to 1,000 words, and are frequently distributed in both the English and the Spanish languages. These notes are issued twice a month and greatly facilitate the work of getting timely information before the people, especially those of the rural districts. The notes are distributed by mail and through the school children to people to whom mail is never delivered. By means of Agricultural Extension Notes the small farmer receives rudimentary information concerning agriculture, the benefit of the results of many and varied experiments conducted by the station, and valuable data that are obtained from other tropical experiment stations.

Correspondence is carried on with anyone who wishes information pertaining to the station or to any feature of the island's agriculture. The aim of the station is to benefit all who are engaged in or dependent upon any phase of agriculture in Porto Rico.

NEEDS OF THE STATION.

During the year three frame dwellings were erected at the station for members of the staff and their families (Pl. III, Fig. 2). The dwellings were constructed from two warehouses which were transferred by the War Department from the Army camp, Las Casas, at San Juan. These houses will supply the urgent needs of the station personnel.

The rainy season in Porto Rico begins in the spring and continues until autumn, when the trade winds shift rather suddenly and the

² Copies of all available publications issued may be had by writing to the agronomist in charge of the station.

dry season sets in and lasts throughout the winter. During the dry season vegetative growth is greatly hampered by the lack of moisture, and in some instances the crops are lost and the regular follow-up work in plant breeding is broken. In former days there was installed at the Hacienda Carmen, where the station is now located, an irrigation system which conducted water from the River Yaguez, bordering the grounds on the south. The water rights still pertain to the property, but funds are needed to put the system in condition to distribute water to all the lowlands of the station. Such a system would greatly enhance the extent and effectiveness of the work of the station.

The station also needs a reasonable appropriation to carry on a campaign for the eradication of the cattle tick which prevails throughout the island. The first dipping vat in Porto Rico was erected at the station and it has been followed by the construction and operation of dipping tanks in all sections of the island. The people have begun to recognize the importance of eliminating the tick and some of them have constructed dipping vats for their cattle. A systematic campaign to dip all infested stock at regular intervals is needed to insure the destruction of the tick, and the expenditure of a reasonable sum for this purpose would yield a great return to the cattle raisers and general stock farmers of Porto Rico.

REPORT OF THE CHEMIST AND ASSISTANT CHEMIST.

By L. G. WILLIS and J. O. CARRERO.

RICE INVESTIGATIONS.

Investigations which have been in progress at the station for several years to determine the effect of different fertilizers on rice production were brought to completion during the year.

Contrary to the findings of other investigators, it was found (1) that rice does not differ physiologically from most plants of agricultural importance in its response to fertilization with nitrogen in the form of nitrates; and (2) that as good results as, or even better than, those obtained from the use of ammonium sulphate can be had from the use of nitrate fertilizers if other factors are not permitted to influence the growth of the plant. In general practice, however, it might be well to continue the use of ammonium sulphate as a fertilizer on account of the susceptibility of nitrates to loss from leaching or denitrification when they are used under conditions that are peculiar to rice culture. From the results obtained at the station it is concluded that nitrate nitrogen, or any of the nitrogen products into which it may be converted in the soil, is not toxic or incompatible to the rice plant.

Reports of rice fertilization tests in the field are very contradictory. In some cases it appears that nitrates considerably increased the amount of plant growth; in others they exerted no appreciable, if any, benefit, and in a few tests they evidently had a harmful effect on the plant. Similarly, in the work of which this is a report, nitrate of soda proved as valuable a source of nitrogen as sulphate of ammonia on a red clay soil when loss by drainage was eliminated; but the average result of all tests was definitely in favor of sulphate of ammonia on a sandy soil, alkaline with carbonate of lime, compared with any form of nitrate used.

When a nitrate was used as a fertilizer in the sandy soil the plants germinated and grew normally until the appearance of the fourth leaf, after which the new leaves invariably showed signs of chlorosis, a condition which may be remedied to some extent by spraying the plant with a solution of ferrous sulphate or other iron salt. When the plants were not sprayed, the chlorosis usually followed one of two courses; either it became more intense until the bud apparently died or, as is often the case, the plants continued to grow, putting out pale greenish yellow, or striped yellow and green, or very finely mottled, leaves until they reached a stage in their growth at which all their new leaves were of a uniform deep green. They then became very thrifty and, heading normally, produced numerous well-developed panicles of grain.

In so far as chlorosis is concerned, the facts cited closely agree with the results obtained by P. L. Gile and J. O. Carrero^a in their study to determine the cause of lime-induced chlorosis of rice.

During the year a study was made to ascertain whether or not the unfavorable action of nitrate fertilizers on rice, as reported by some investigators, is due to the effect of the unassimilated residues of the physiologically alkaline salts on the availability of iron in the soil. The results obtained indicate that this is probably the case since, in an experiment in which chlorosis was largely controlled, all comparisons between nitrate of soda and sulphate of ammonia showed that nitrate nitrogen is at least equal to ammonia nitrogen for the fertilization of the rice plant.

An examination of some of the results obtained in the tests of nitrogenous fertilizers for rice leads to the belief that chlorosis, due to a lack of assimilable iron, occurs only on certain soils and under definite conditions. On the red soil above mentioned, chlorosis did not follow treatments with hydrated lime in any amount up to 5 per cent, neither did it occur at any degree of alkalinity up to pH 8.7, nor with any form of nitrate or ammonium salt used as a

^a U. S. Dept. Agr., Jour. Agr. Research, 20 (1920), No. 1. pp. 33-62, pl. 6.

fertilizer. On the sandy soil, naturally alkaline with carbonate of lime, however, chlorosis followed the application of certain fertilizers.

It was observed on the sandy soil that chlorosis invariably followed applications of nitrates or of ammonium phosphate in sufficient amount to supply enough nitrogen for thrifty plant growth. This observation leads to the belief that the development of lime-induced chlorosis of rice and possibly of other plants in calcareous soils is governed, not by the precipitation of the iron in the soil by the lime, but by the kind of fertilizer salts that are used and the nature of their unassimilated residues. Since the concentration of these residues is greatest at their source, it is evident that the growing plant modified the condition of equilibrium in the soil. The only true medium in which the plant grows is that part of the soil that is in actual contact with the plant root and is subject to its dynamic influence.

MANAGEMENT OF CANE SOILS.

The study of nitrogen economy in cane soils was continued according to the plan outlined in an earlier report,⁴ but no quantitative results were obtained owing to the nature of the investigations. Evidently a large amount of supplementary work must be done in connection with the experiments before determination can be made of the most suitable leguminous green-manure crop to use in cane rotation, the best time to plant this crop, and the most advantageous stage at which to plow it under. Apparently, also, moisture conservation is a matter of great importance, and the relation of green manuring to the water economy of the soil will have to be considered.

MISCELLANEOUS ANALYTICAL WORK.

During the year approximately 150 seedling canes were analyzed by the station. The policy of testing and analyzing materials that were sent in from various sources was continued, the work being done free of charge in every case where the results were thought to be of general agricultural interest. Many soils were likewise submitted for testing to determine their fertilizer requirements, but the station found it impossible to supply the information desired, except in a very general way. More complete knowledge is needed regarding the fertilizer requirements of the different soils of the island and the adaptability of different cultural methods to the various crops.

⁴ Porto Rico Sta. Rpt. 1919, p. 14.

REPORT OF THE HORTICULTURIST.

By T. B. McCLELLAND.

LEGUMES.

The third year of the variety test of beans was completed in 1921. On account of the present poor irrigation facilities, the test is limited to only one annual planting, when a full crop is desired. The planting of the third season again demonstrated the superiority of the varieties collected in the Caribbean region over the varieties commonly grown in and imported from the North. Of the Caribbean sorts, the black and the white beans were the most prolific, while of the northern varieties, Extra Early Valentine, Fordhook Favorite, and Robust made the largest yields.

The station made two extensive plantings of selections from the black Venezuelan bean to obtain, if possible, a type which will be as prolific as the Venezuelan and of a color that will be acceptable to the local market. The black bean, although a heavy yielder, is sold on the Porto Rican markets at a greatly reduced price on account of its color.

Comparative studies of several cover crops are in progress. The bush velvet bean never makes the growth at this station that it is reported to make on the mainland. It covers the ground for a much shorter period than do the twining varieties and matures its seed in the time of heavy rains if it is planted at the season for most favorable growth. The seeds are borne so near the ground that they are continually spattered with mud and water, which causes them to sprout before they can be picked. For this reason it is difficult to obtain seed for future plantings. The twining sorts are best adapted to local conditions.

Crotalaria juncea gave the highest dry weight production of the various cover crops under test. *C. striata*, cut at 149 days from planting, gave 7.35 tons of green matter per acre, or 2.1 tons cured. *Tephrosia candida*, cut 266 days after planting, produced at the rate of 5.67 tons of green matter per acre, or 2.61 tons sun dried. Unlike *Crotalaria juncea*, which grows so rapidly that it is well able to hold its own against encroaching weeds, *C. striata* and *Tephrosia candida* grow slowly and in their early development need protection against vegetation of more rapid growth. *T. candida* makes a dense cover and produces strikingly handsome white flowers. Owing to its woody growth, the task of removing *T. candida* from the ground is more laborious than in case of some of the other cover crops.

ROOT CROPS.

During the year the station tested various crops, including sweet potatoes, yams, yautias, and taros, to determine their comparative

yields. In a comparative planting of 34 varieties of sweet potatoes in red clay soil, Key West was the most prolific, giving an average yield of 1.08 pounds per linear foot of row. Pierson (No. 5957^a) was second and No. 11285 ranked third. Ex-Red Carolina (No. 5970), Early Carolina (No. 5963), Nancy Hall (No. 5966), and Pumpkin (No. 5999), were the least productive of the sweet potatoes. The largest tubers were produced by Dahomey and Porto Rico (No. 21406). The smallest tubers were produced by Early Carolina and No. 7980. Nancy Hall, Mamey, Florida (No. 5950), Key West (No. 5967), and No. 21406 were considered of superior table quality. These and some additional varieties of sweet potatoes are being tested again. A number of imported varieties were distributed by the station.

A test was made with 6 varieties of yams, totaling 244 plants, to learn whether they could be grown without support. The staked yams yielded a little over 385 pounds in comparison with 67 pounds from the unstaked plants. The maximum difference for any one variety was with the Potato yam, the staked vines of which yielded an average of 4 pounds of tubers per plant as compared with an average yield of 12 ounces from the unstaked vines. The minimum difference in any one variety was greater than 3 to 1. Staking affected not only the weight of the total production of each plant, but also the size of its tubers. The unstaked plants produced no large tubers, and of the tubers produced a large proportion were too small to be marketed. The available data from the yautia and taro planting of the last ten years were reviewed during the season and the less desirable varieties were eliminated from the tests.

PLANT INTRODUCTION.

During the year the plant *Talinum verticillatum* was introduced into Porto Rico from the Philippine Islands where it had been imported from Java. This is an upright perennial herb, having tender, fiberless, and succulent leaves that are used like spinach. It is propagated readily from cuttings and grows rapidly. Except for the fact that it is rather subject to root disease, this plant seems well adapted to local conditions.

VANILLA.

A root disease, presumably *Fusarium* sp., made such inroads in the vanilla plantings at the station during the year as to necessitate the use of fertilizers on the plats. Remedial measures are being tried but they are apparently not very promising. Calculations of the time requisite for curing vanilla beans were made from the recorded data on more than 10,000 pods. Two per cent of the pods were con-

^a These numbers are Arlington Farm accession numbers.

sidered cured or sufficiently dry for storage within three weeks after picking. From the fourth to the tenth week the percentages were 8, 14, 29, 16, 13, 11, and 4, respectively. The remaining 3 per cent of pods required between 10 and 16 weeks to cure.

A common practice in some vanilla-growing countries is to "needle" the beans at the beginning of the curing process. This consists in making shallow full-length slits on the three sides of the pods with a pen point or with two pins or needles inserted in a small cork or wooden holder. Needling was tried on several lots in the curing of the 1920 crop, and was followed by alternate sunning (exposure to the sun) and sweating (closely wrapping the beans in blankets). The drying was greatly accelerated by needling, but in appearance the product was less glossy or oily than the check lot and did not keep as well. The lot which was needled to a depth of a little less than one-sixteenth inch by two pins set one-sixteenth inch apart, was reduced by the ninth day to 27 per cent of its original weight. The check lot at this time was reduced to only 69 per cent. The needled beans were no longer exposed to the sun, but those in the check lot required sunning for a period of from 6 to 11 days longer. The needled beans were sufficiently dry for storage in from 14 to 16 days after needling, while those in the check lot required from 5 to 17 days longer.

COFFEE.

The cooperative experiment for the control of the coffee-leaf disease (*Stilbella flavida*), begun in 1917, was concluded during the year and the data were submitted for publication.⁶

In a cooperative fertilizer test on coffee, nitrate of soda, applied semiannually for five years, failed to cause any increase in the crop. The plan of the experiment was therefore changed to compare nitrate of soda with sulphate of ammonia. In a planting of 60 coffee trees at the station farm, the plat which received the sulphate of ammonia made four times as great a yield as did that which received the nitrate of soda. Prior to this there had been six semiannual applications of fertilizer furnishing equivalent amounts of nitrogen in the two forms. As the trees were young and in short rows of five each and the plats consisted of alternate rows, conditions were very uniform for the two plats under comparison.

COCONUTS.

The cooperative experiment begun in 1915 to determine the effect of fertilizers on the growth of young coconut palms was continued

⁶ Porto Rico Sta. Bul. 28, "The Coffee Leaf Spot (*Stilbella flavida*) in Porto Rico," copies of which may be had by addressing the agronomist in charge of the station.



FIG. 1.—FIVE-YEAR OLD MAHOGANY TREES.



FIG. 2.—HOUSES CONSTRUCTED FROM LUMBER FROM ARMY CANTONMENT.



FIG. 2. — KENTIA PALM.

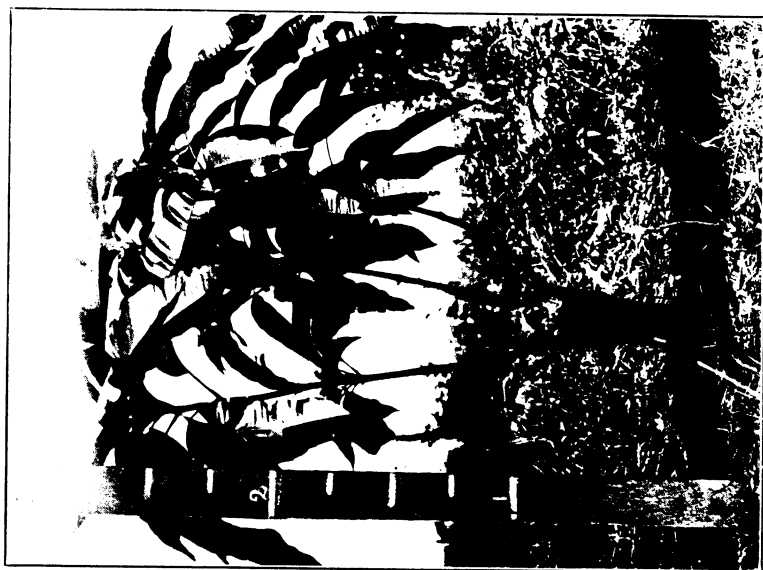


FIG. 1. — MANGO GRAFTED ON STUMP.

during the year, plats of 10 trees each again receiving semiannual applications of complete and incomplete mixtures of chemical fertilizers, as well as tobacco stems, stable manure, and seaweed in combinations with chemical mixtures. During the first 18 months of production the best yield was made by the plat to which common salt (sodium chlorid) only had been applied. Nine trees in this plat have matured nuts, while only two have done so in the check plat. From four to five trees have fruited in each plat which received incomplete fertilizer, and from four to nine trees in each plat which received complete fertilizer. Salt has been found to be so beneficial that it will be tested on a much larger scale in an old coconut grove where records have been kept of the individual yields of several hundred trees for over eight years.

MANGOES.

Among the imported mangoes in the station orchard are a number of varieties which have never fruited. Some of these are large trees which were planted 16 years ago; others are younger trees of sufficient size and age to fruit, but fail to do so. In an attempt to induce fruiting, a number of these unproductive varieties and a few of the younger trees were girdled. The test included 37 trees of 17 varieties. From one to four limbs on each tree were girdled between November 30 and December 2, 1920, a band of bark about three-quarters of an inch in width being removed from each. The limbs selected ranged chiefly from 6 to 10 inches in circumference. The cambium in various instances had practically filled in the cut area four months after girdling, but it did not in any instance re-establish a connection between the girdled branch and the tree. About 9 per cent of the limbs had bridged the cut area in six months. Blossoming was induced only on two specimens of the youngest trees girdled, these being 6 or 7 years of age. One of the two specimens also blossomed and fruited on an untreated limb, but the other, Chempadan, blossomed on the girdled limb only. None of the other trees blossomed at all, either on the girdled or the untreated limbs. Among the older trees the branches of which were girdled on from three to six of each variety, were the varieties Mulgoba, Madras, Bombay Yellow, and Bombay Green. These four and a number of other Indian varieties give only small promise of fruiting in this locality unless a means can be found to induce blossoming. The Cambodiana or Chinese mango fruited well during the year. The record of a number of years indicates that the Cambodiana is one of the leading imported varieties for this locality, both in regard to quality and to production. The planting and observation of Cambodiana seedlings will be continued. From these plantings compari-

sons may be made between the produce of the several seedlings springing from a polyembryonic seed.

The station is continuing to urge the propagation of some of the better varieties of introduced mangoes, and it has been very successful in grafting them to stumps of inferior sorts (Pl. IV, Fig. 1). Recently the growing of ornamental palms for shipment to the States has developed into a promising industry. Some of these ornamentals have proved well adapted to Porto Rican conditions (Pl. IV, Fig. 2).

REPORT OF THE PLANT BREEDER.

By THOMAS BREGGER.

GENERAL WORK.

The principal crops upon which work was commenced during the year included corn, rice, soy beans, cowpeas, beans, vanilla, and certain forage grasses.

Corn.—The work with corn was largely a matter of growing selections of native varieties for crossing inter se and with varieties imported by the Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry, United States Department of Agriculture,⁷ from the mainland and from Turks Islands. Reciprocal crosses were obtained between the varieties Hickory King, Eureka, and a yellow flint from Henderson, and native Porto Rican yellow dent corn. These crosses were made in the spring of 1921 and have not yet matured sufficiently for planting. Certain selections of native yellow dent and a yellow flint variety from Turks Islands were crossed in August, 1920. During the winter dry season a few plants of some of these latter crosses were grown under irrigation, and second-generation plants are now growing in the field. In July, 1920, a cross was obtained between Henderson's Astor sweet corn and native yellow dent. The first generation plants were grown during the past winter under irrigation, and the second generation recessives are now growing in the garden. In appearance these plants are intermediate between sweet corn and field corn, tasseling and silking earlier than the native field corn parent and a bit later than the sweet corn parent. These plants have not yet matured their seed. During the winter the varieties Stowell's Evergreen and De Rue's Golden Giant were planted, together with several strains derived from Guatemalan sweet corn that was obtained from the Office of Crop Acclimatization and Adaptation Investigations, Bureau of Plant Industry, United States Department of

⁷ Copies of Porto Rico Sta. Circ. 18, "The Selection of Seed Corn in Porto Rico," issued in September, 1920, may be had by applying to the agronomist in charge of the station.

Agriculture. With the exception of one strain that was obtained, by crossing a Black Mexican with a Guatemalan variety, the sweet corn was a failure. In this case, reciprocal crosses were obtained with an F_1 hybrid of native with Turks Islands yellow flint. The first generation plants of these reciprocal crosses are now growing in the garden and their seed should be available for growing under irrigation this coming winter. It is hoped to develop from these crosses a strain of sweet corn which will be better adapted to the lowlands of Porto Rico than are the present varieties introduced from the mainland.

In January, 1921, some selections were made in a field of Porto Rican corn on the south coast, near Lajas. With these selected ears it is intended to start an ear-to-row cooperative experiment, having for its purpose the isolation of better yielding strains of corn adapted to the region, and the demonstration of the greater value of seed selection in the field over crib selection.

Rice.—On the resignation of the agricultural technologist, W. A. Mace, in July, 1920, the work on rice, carried on in cooperation with the Office of Cereal Investigations, Bureau of Plant Industry, United States Department of Agriculture, was turned over to the plant breeder. Notes were completed on heading, tillering, and yields of 149 selections planted in 17-foot nursery rows by Mr. Mace. A few plants of Honduras and Wataribune, obtained from the Office of Cereal Investigations, and six selections of native rice were grown in pots in the greenhouse. Attempts to cross them met with small success, only 8 viable seeds out of a total of 533 pollinations being produced. It is hoped that with improvements in technique and manipulation better results will be obtained in the future.

Kidney beans.—A planting was made of red kidney beans that were bought on the local market as "Americana." Mass and individual selections of this variety were made and will be continued.

Soy beans and cowpeas.—The station is continuing to make selections from the soy-bean varieties Mammoth, Virginia, Haberlandt, and Hahto, and from the cowpea varieties New Era, Brabham, and Groit. In the past four or five years the soy-bean varieties introduced and tried at the station have included the Mammoth, Chiquita, Virginia, Haberlandt, Wilson Five, Tokio, Bachet, and Hahto, and the cowpea varieties Groit, Brabham, Early Buff, Early Catjang, California Blackeye, Forty-Day Blackeye, Whippoorwill, New Era, Iron Conch, and Monetta. The reduction in the number of varieties tested may be ascribed in part to unfitness of all but four varieties of soy beans and three varieties of cowpeas, and in part to the fact that all the seed of the other varieties was distributed throughout the island. Trial of the above-mentioned varieties will be continued with seed

obtained from the Office of Forage Crop Investigations, Bureau of Plant Industry, United States Department of Agriculture.

Forage grasses.—To determine their comparative yield for forage purposes, Guatemala grass (*Tripsacum daniellii*), Napier or elephant grass (*Pennisetum purpureum*), Job's-tears (*Coix lachryma-jobi*) from the Philippines, teosinte (*Euchlaena mexicana*), and Zwinga cane (*Saccharum officinarum*) have been planted in small plats that are uniform in texture, surface, and fertility.

Vanilla.—During the year several crosses were made between *Vanilla planifolia* and *Vanilla* sp. of Venezuela. *V. planifolia* is subject to a root disease which does considerable damage. *Vanilla* sp. of Venezuela apparently is not attacked, or at least it is not injured by the disease.

STORING SEED.

To keep seed viable over periods of unfavorable weather, especially ear remnants in ear-to-row breeding, the station has been making use of 5-gallon oil cans fitted with milk-can lids. Fresh unslaked lime is put in the containers with the seed and the cans are then made air-tight with paraffin. While this method is proving very useful at the station, it is only a makeshift. What is needed is an air-tight room wherein large quantities of seed can be stored. Such a room should be constructed so as to remain perfectly dry for an indefinite period.

REPORT OF THE ASSISTANTS IN PLANT BREEDING AND HORTICULTURE.

By W. P. SNYDER and J. A. SALDAÑA.

SUGAR CANE.

The first plantings of the station's seedling canes of 1919 were made in five-hole lots in April, 1920, and the first harvesting was done during March and April, 1921. Thirty-one of the harvested seedlings were saved for further testing at the station, and some of the cuttings were sent for trial to the Pagán Central, at Añasco.

Notes were taken on the varietal characters and degree of resistance to the mottling disease of the seedlings of the different parents for comparative purposes. It was observed that the seedlings of cane variety D. 109 differed from those of cane variety P. R. 260 in degree of resistance to the mottling disease and in habit of growth. The seedlings of cane varieties D. 109 and Java 36^s averaged

^s The Java 36 referred to is No. 36 P. O. J., the seedlings of which were grown at the experiment station, East Java.

higher in resistance to the mottling disease than did the seedlings of the other varieties, as will be seen from the following table:

Summary of observations made on original seedling canes in March, 1920.

Name of parent.	Average resistance to mottling disease of seedling plants.	Average sucrose content of seedling plants.	Habit of growth.	
			Number of erect plants.	Number of plants inclining and trailing.
	<i>Per cent.</i>	<i>Per cent.</i>		
P. R. 260.....	2.28±0.038	13.62±0.116	111	49
D. 109.....	3.33±.060	12.92±.116	29	56
P. R. 317.....	2.13±.095	13.57±.334	8	7
G. C. 1480.....	2.21±.175	15.36±.339	5	10
Java 36.....	3.63±.093	12.40±1.250	5

It is thought that the number of seedlings produced by cane variety Java 36 is too small to warrant the drawing of conclusions. The influence of the habit of growth of the parent varieties is very evident in the large number of erect-growing seedlings that were obtained from cane variety P. R. 260.

The degree of resistance to the mottling disease was obtained by grouping the seedlings into the following classes: (1) Severely diseased, (2) diseased, (3) slightly diseased, (4) very slightly diseased, and (5) not diseased.

When the assistant in plant breeding was reappointed after an absence from the station of 10 months, the station had no good pollen-producing varieties that were old enough to arrow the following winter. Germination in most of the seed boxes was therefore very unsatisfactory. A fair germination was obtained from a number of arrows of cane variety D 117, which was obtained from the Guánica Central fields near Añasco. Two other factors handicapped the work: The practically complete failure to germinate of all arrows that were bagged, the result, most probably, of too high a temperature within the bags, as noted by Barber,⁹ or to injury to the stalks; and the death of approximately two-thirds of the seedlings shortly after they were transplanted to the field, due, no doubt, to their small size at the time of transplanting and the excessive soil moisture. A few arrows of the variety Cristalina, which was obtained from Aguirre Central, produced five seedlings, all of which survived the transplanting. The total number of surviving seedlings is only little more than 200.

The station planting of cane S. C. 12/4, introduced from the Virgin Islands station in 1919, has continued to make vigorous growth,

⁹ Barber, C. A. Sugar Cane Seedling Work in India. Part II. The Internat. Sugar Journ., 22 (1920), No. 258, pp. 307-312.

notwithstanding its having been attacked by the mosaic disease. Cuttings of this cane have been distributed to a number of planters for trial. Several other varieties have since been introduced from St. Croix and from Java for trial at the station.

FIELD CORN.

The object of the work with corn is to isolate some of the different types of native corn, to increase the yield, and to determine the effect on the yield of grain of the selection of different types of plant, ear, and kernel. It is planned to maintain continuous self-fertilization in all lines of selection, as far as possible, with the purpose of ultimately crossing the best self-fertilized strains. Dry weather following the planting of the past season caused the loss of much of the seed, and the plats were replanted with corn that had been imported from Venezuela. The Venezuelan corn produced a vigorous plant growth, but it apparently is not a good yielder of grain, because the plants began to dry when the ears were still small.

Notwithstanding the fact that the station has found the development of some of the acclimated varieties of the island to be the best way to improve the corn crop, it conducted a further test with imported varieties from Queensland for the purpose of selecting the best for hybridization work. The varieties tested included Reid's Yellow Dent, Improved Yellow Dent, Boone County White, and Star Leaming. These four varieties made vigorous growth until the appearance of the silks and tassels, when they were attacked by mosaic disease, followed by a reddening of the leaves and a drying up of the entire stalk. Not an ear was harvested from the whole plat, consisting of approximately half an acre.

SWEET CORN.

A great many varieties of sweet corn from the States have been tried without success at the station year after year. Failure is undoubtedly due to their inadaptability to tropical conditions. The station has, therefore, been endeavoring to produce by hybridization a variety which will have the requisite hardiness to withstand tropical conditions.

A further test for the purpose of selecting the most vigorous variety for hybridization work was made in the spring of 1920 with the varieties Golden Bantam, Stowell's Evergreen, Hiawatha, Pocahontas, Henderson's Astor, and Henderson's Sugar. The last-named variety, being the most vigorous, was selected as the male parent. The mother parent was a white native corn (strain S), which has been grown for some generations at the station and which

is doing well as a field corn. Several crosses were made between these two varieties, and from them a first generation ear was selected for the 1921 planting. Every single kernel, with the exception of 8 out of 81 where mosaic disease appeared, germinated and produced a strong, healthy stalk. This planting was made on April 9, and the silk and tassels began to appear on May 26. Reciprocal crosses were then made between all the healthy plants. Harvesting began on July 7 and ended on August 1. The 61 reciprocal crosses segregated into sweet and starchy kernels. The greater number of the second-generation hybrids showed very promising characters, which will be studied in later generations. A number of the best ears were saved for future planting.

In the hybridization work there occurred two accidental crosses which may be promising. The male parents were evidently yellow native field corn and the St. Croix Blue Hybrid,¹⁰ and the female parent in each case was Henderson's Astor. Some ears, which correspond to the second generation, were saved for planting during the coming season.

WHEAT.

A number of Indian wheats, together with the varieties Regenerated Defiance, Early Baart, Sonora, Bluestem, and Marquis, were planted in a small plat during the winter. The plantings were supplied with a minimum of irrigation in order that observations might be made on the behavior of the wheat under comparative drought conditions. Mixed fertilizer was applied at the rate of 5 grams per 4-foot row. An unusually large amount of rain fell just at the blooming period and facilitated the spread of a fungus disease that considerably damaged the grain.

The Early Baart and Sonora varieties failed to germinate. The varieties Defiance, Bluestem, and Marquis were practically failures, while the Indian wheats gave variable yields, ranging from averages of 10.7 to 54.6 grams per 4-foot row. The season of growth was in most cases very short, ranging from 97 to 145 days, and the texture of the grain, with few exceptions, was rather soft. A few well-filled bearded heads appeared in the plantings of Marquis and Bluestem and were saved for future testing.

TOMATOES.

Several pests handicap the work of growing tomatoes at Mayaguez. Nematodes are present in such numbers that practically all tomato plants grown at the station are heavily infected with root knot.

¹⁰ St. Croix Blue Hybrid is the result of a cross between black Mexican sweet corn and St. Croix native field corn. It was bred by and obtained from the Virgin Islands Agricultural Experiment Station.

The plants, however, manage to produce a fair crop unless they are attacked by some other trouble. A very destructive disease of the tomato plant in Porto Rico is due to the *Cladosporium* fungus, which destroy the leaves and ultimately the whole plant. Spraying will not hold this fungus in check during the rainy season. During the winter a new trouble appeared, causing affected tomato plants to stop growth, the young leaves to partially roll together and stand erect, and the entire plant to become stiff and rigid. This disease was probably superinduced by unfavorable soil conditions. The entire spring crop was affected while in the seed boxes, but overcame the trouble after being transferred to the field and fertilized. During the year a wilt-producing disease attacked the tomato crops at the station and practically destroyed the whole planting. A diseased plant was sent to Washington and examined by W. A. Orton, pathologist in charge of Cotton, Truck, and Forage Crop Disease Investigations, Bureau of Plant Industry, United States Department of Agriculture, who reported no evidence of either *Fusarium* or bacterial wilt, but severe infection by both nematodes and *Rhizoctonia*.

One of the objects of the tomato work is to obtain, if possible, strains that will be resistant to disease. A first generation cross between the Lares Native and Stone varieties showed apparently strong resistance to the trouble last mentioned. Both parent varieties were considerably damaged, but to a less degree than were the majority of the plantings. The tomato crop was not seriously damaged by *Cladosporium* during the year. Injury by this fungus to each variety differed in extent, however, and an effort is being made to select strains which will prove resistant to its attack. Another object of the work is to improve the size and quality of the native tomato by crossing it with commercial varieties. A cross between Insular Station Tomato No. 443 and the Diener, a wilt-resistant variety, has been carried through the second generation, but it is very susceptible to attack by *Cladosporium* and most of the plants are poor yielders. A cross between a native ridged tomato and the Greater Baltimore has also been carried through two generations and gives hope of producing a good fruit. Several other first-generation crosses have been grown. The tomato work of the former assistant horticulturist was taken over in July, 1920, and selections have been made from Insular Station Tomato No. 443 through two more generations. This tomato exhibits much variation, but on the whole the fruits are small, somewhat rough, and rather bitter in flavor. No very marked improvement has been obtained with this tomato.

The greater part of the spring planting consisted of second-generation plants which were the progeny of a cross between the varieties

Greater Baltimore and Native, and between Insular Station Tomato No. 443 and Dierfer, a California tomato.

MUSKMELONS.

A cross was made in 1919 between the large native muskmelon and the variety Salmon Tint Pollock, which is a Rocky Ford type of melon, and also between the native melon and the A. and M. Hybrid Casaba.¹¹ The native melon is large, oval, late maturing, and somewhat resistant to downy mildew, which is very destructive to the common commercial melons grown at the station. The first and second hybrid generations were grown during the year, the first generation being grown under glass during the rainy season.

Resistance to mildew was evidently not a dominant factor, because the progeny of the crosses was killed sooner than were the native plants that were grown for comparative purposes. The plants of the second generation, grown from native seed, showed evidence of contamination with pollen from the crossed plants, and they could not, therefore, be used as a basis for comparison. When the two commercial varieties were used as parents, however, the planting proved a failure, while most of the hybrid plants produced fairly good melons.

In the first as well as in the second generation plants from self-pollinated seed, a perplexing variety of shapes was produced, including oval, ovate, globular, and pear-shaped fruits. The inheritance of season of maturity was evidently intermediate in the first generation and showed great variation in the second generation. Netting did not show up until the second generation, with the exception of a few traces at the stem end of the first-generation fruits. The second generation of the Salmon Tint Pollock cross exhibited all degrees of netting, from completely smooth fruits to heavily netted ones. Of the first-generation fruits of this cross, 10 had green flesh and one had pale yellow flesh. Nine out of twelve second-generation plants produced green-fleshed fruits, and three produced fruits with more or less yellow flesh. All the fruits of the Hybrid Casaba cross had deep yellow flesh in the first generation, and six out of seven in the second generation were also yellow fleshed. The seventh plant produced fruit having white flesh. The edible quality was poor in the first generation, because the fruits were not properly developed, and in the second generation all degrees of quality were obtained. Further selection will be made with the aim of obtaining desirable types of high-quality fruit adapted to Porto Rican conditions.

¹¹ The letters "A" and "M" are the initials of the seedmen from whom the varieties were obtained.

A trial planting was made on the station grounds on the Mesa back of Mayaguez of the varieties Hero of Lockinge, Blenheim Orange, Sutton's Superlative, Rocky Ford, Berry, Flat Jenny Lind, Large Hybrid Casaba, Honey Dew Casaba, and the native melon. Good fruits were produced by the varieties Rocky Ford, Berry, Honey Dew, and the native melon. The English varieties were failures. All the plants received commercial fertilizer, and half of the planting was treated with about a pound of rotted manure per plant, while the other half was left without manure. The effect of the manure was very noticeable, the plants which were not treated making poor growth and producing only a few undersized fruits.

BANANAS.

A planting made in 1919 of Chamaluco bananas selected for resistance to the Panama disease did very poorly. Only one bunch had been produced by the spring of 1921, and most of the plants showed unmistakable symptoms of Panama disease. These plants were removed from the plat, and a few of the most vigorous were chosen for replanting, together with a number of apparently healthy suckers from an old plat of unselected plants. A number of slightly diseased suckers were planted for purposes of comparison. A fertilizer experiment was started on part of the plat to ascertain the effect of wood ashes and tobacco stems on the Panama disease. An experiment was begun in September, 1918, to compare the effects of lime, ashes, acid phosphate, cyanamide, tobacco stems, stable manure, and rice straw as fertilizers, and of *Centrosema plumerosa*, cowpeas, and black velvet beans as cover crops. After two years, an examination made of the amount of disease injury under the different treatments gave no conclusive results.

MISCELLANEOUS WORK.

It has been impossible to undertake further work with grapefruit. About 300 2-year old seedlings from crosses between the Duncan and Triumph varieties are being grown. A planting has been made of Hawaiian, Mexican, and native papaya plants with the purpose of improving the yield and quality of the fruits by cross-breeding. On the Mesa back of Mayaguez a fall planting was made of white clover, Peruvian alfalfa, and white sweet clover. The white clover was a failure. The alfalfa and sweet clover have made a fair growth where both acid phosphate and lime were applied to the soil. A spring planting of sweet clover is making good growth.

REPORT OF THE ENTOMOLOGIST.

By W. V. TOWER.

MOTTLING DISEASE OF SUGAR CANE.

The mottling disease of cane is still causing heavy losses in Porto Rico. Many of the new seedlings and practically all of the native varieties are infected. A number of experiments have been carried on by the station to determine whether this disease is transmitted by insects. Young cane often shows a secondary infection which is apparently the work of insects, but so far the station has not been able to determine what insect, if any, causes it. Seventy-six potted seedlings were under observation during the year, not one of which developed the mottling disease as the result of transmission by insect. The station did not limit its experiments to insects which were obtained from infected cane, but also included insects that were taken from native grasses and weeds growing in the cane.

During the spring of 1921 the common yellow plant louse (*Sipha flava*) was very abundant and stunted the growth of cane in many fields. Uba cane especially was in some instances seriously damaged by it. The beneficial insects accompanying the louse were not in sufficient numbers to hold it in check until the rains set in, and as a result whole fields turned yellow and many of the leaves died. Other varieties of cane were affected, but none so seriously as was the Uba cane. The yellow plant louse was found in great numbers on malojillo grass, from which it spread to the cane. In some instances the infection was so heavy that the grass turned yellow and many leaves became brown. The presence of this insect in so many fields infected with mottling disease suggested that the louse might be responsible for the transmission of the disease. Trials were therefore undertaken to determine whether or not this was the case. Insects were transferred to healthy young canes which had been grown in 5-gallon tins and covered with cheesecloth from the time they were set out to protect them from insect attack. These canes were grown from selected seed obtained from the south side of the island, where the disease has been held in check by constant roguing and selection. They were protected from all insects from the time of planting. The cane which was subjected to insects obtained from diseased canes failed to develop the disease. Insects from grasses and weeds that were growing in diseased canes were then transferred to these healthy plants, but in no case did disease develop. The yellow plant louse was found on a number of different plants, including malojillo, grama, yerba dulce, elephant grass, sorghum, orchard grass, corn, wheat, and morning-glories. Insects obtained from all of these plants were transferred to healthy cane. In a number of instances where

field corn showed a peculiar mottling, insects were taken from it and transferred to healthy cane.

In transferring insects to cane two methods were practiced: In the first method, the plant lice were lifted by means of a camel's-hair brush from the diseased cane and placed on the healthy cane. This method was followed only where insects were obtainable, the insects being placed in small bottles fitted with a tube made of wire gauze. These cages were slipped over healthy leaves, or over growing buds or shoots, and enabled one to observe the insects and remove the cheesecloth without touching them. The collection of moisture in the bottles, however, caused many of the insects to stick to the sides. Doubtless tubes made of wire gauze alone would be better. This method was found satisfactory for the control of such active insects as leafhoppers, springtails, and thrips. In the second method, pieces of leaves harboring large numbers of insects were cut from the infected plants and transferred to the healthy specimens. The lice established themselves in strong colonies on the young growing cane as the leaves died. This method also was tried when springtails, red spiders, and thrips were transferred to cane.

Other insects were tested as carriers of the mottling disease. A number of transfers made of the common green plant louse of corn and sorghum to cane failed to develop the disease. The black thrips of cane and the ever-present springtail were tried many times, but no infection could be attributed to them. Large numbers of leafhoppers in all stages of growth were transferred from diseased cane and corn to healthy cane, and in some cases the full life history was carried through on the caged cane. The common green sugar-cane leafhopper (*Kolla similis*) was also tried. This insect, as well as a pale yellow straw-colored leafhopper, is frequently found on young cane, and at times is very abundant. The nymphæ of the latter are whitish and are considered a new species by Smyth,¹² who terms them false mottling leafhoppers. A smaller species resembling *K. similis* also appears on cane. It has the same general color as, but is smaller than, *K. similis*. These insects were also transferred. Others tested included the smoky-wing leafhopper, the chocolate-colored specimen having wings transparent at the apex, and the little dark brown hopper having the basal portion of the wing brown and the tip transparent. Strong colonies of the sugar-cane mealybug developed in a number of pots, being brought in from the outside by ants.

Other species tried were *Cicadella* (*Tettigonia*) *sirena*, *Oliarus cinereus*, and the West Indian cane fly (*Stenocranus* (*Delphax*) *saccharivorus*), none of which transmitted the disease. During the

¹² Smyth, E. G. Insects and Mottling Disease. In Jour. Dept. Agr. Porto Rico, III (1919), No. 4, p. 106.

year the only infection in the greenhouse occurred in three pots which were planted with single stools of seedling cane B 6450. When the original stool was taken up and divided it seemed perfectly healthy. The three plants were infested with yellow plant lice (*Sipha flava*) taken from diseased cane, malojillo, and grama grass growing among diseased cane. The same experiments were carried on many times with this yellow plant louse, obtained from diseased cane, malojillo grass, and grama grass, but no infection took place. Doubtless the disease was dormant in the canes when they were taken up and immediately showed itself because the power of resistance in the plants had been weakened by transplanting.

TICKS.

Monthly studies were again carried on with ticks taken from cattle, goats, horses, and dogs. Some of the cattle ticks were kept in the insectary; others were placed in the open in a weather shelter of the standard Weather Bureau type. Efforts to carry the ticks through long periods were much more successful this year than they have been heretofore at this station. The conditions under which ticks are kept have much to do with their longevity. From the data accumulated at the station, it would seem that the starvation period is much longer than was at first thought.

The interest shown in the work of eradicating the tick has been general. A number of privately owned dipping tanks have been constructed and the insular legislature has enacted a law providing for municipal dipping tanks. By the passage of a law making it compulsory to dip the animals at regular intervals, the stock raiser and farmer in Porto Rico should have no difficulty in exterminating the tick. Such an extermination will doubtless encourage many of the stock raisers to import improved cattle.

From July 1, 1920, to June 30, 1921, 1,954 head of cattle were dipped in the vat at the station. This vat is corrected once every three weeks, chemicals being added to increase the strength of the solution or water being added to dilute it. It is cleaned and the solution renewed once every five months. Cattle within a radius of 5 miles are brought to the station for dipping. There are on the island at the present time 98 dipping vats, 19 of which belong to the insular government.

BEE INDUSTRY.

With the decrease in price of honey and wax, there has been a corresponding lessening in the interest formerly manifested in the bee industry. The past season was more favorable for honey production than a year ago, when the island was visited by a severe

drought. Only a few queens are being introduced into Porto Rico and as a result the stock is deteriorating.

MOSQUITOES.

The result of the mosquito survey, made during the fiscal year 1920 and mentioned in the last annual report, has been published as a circular of the station.¹³

REPORT OF THE SPECIALIST IN FARM MANAGEMENT.

By H. C. HENRICKSEN.

THE CITRUS-FRUIT INDUSTRY.

The different lines of investigation of this division were reported upon in detail in the last annual report.¹⁴ Certain of the citrus-fruit investigations, as outlined last year, were continued. The work undertaken to determine the present cost of producing and handling fruit in Porto Rico and to devise methods of reducing the cost was finished during the year; that carried on to obtain data on decay of fruit in transit and to find methods of preventing this decay was practically completed.

Cost of production.—As was stated in last year's report, it is impossible to obtain accurate data on cost of production. The station has prepared, in mimeographed form, an outline of plantation cost accounting, copies of which may be had upon application to the station. This work has been discontinued for the present.

Fruit rot.—The study of decay in transit, concerning which a preliminary report was made last year, was again continued as the main investigation. During November the specialist in farm management stayed in New York to study some phases of the problem by observing the condition of the fruit cargoes arriving from Porto Rico. December was spent principally in Washington, where a study was made of the respiration of fruit. The remainder of the fiscal year was devoted mainly to a study of fruit rot. This investigation included studies of transpiration and respiration, as represented by loss in weight of the fruit, and the relation of this loss to the rotting of grapefruit, the effect of the products of respiration on the development of the decay, means by which fungi gain entrance to the fruit, and the influence of temperature, ventilation, and humidity upon the development of rot.

¹³ Porto Rico Sta. Cir. 20, "Mosquito Survey in Porto Rico," copies of which may be had by applying to the agronomist in charge of the station.

¹⁴ Porto Rico Sta. Rpt., 1920, pp. 27-37.

Practically all the decay of Porto Rico grapefruit is due to the stem-end rot caused by the fungus *Diplodia natalensis*. The fungus does not appear to be able to enter the fruit through the uninjured rind. Normal entrance is through the short stem, when cut, or through the cavity, if the stem is pulled from the fruit. As the disease is nearly always found about the stem, the name stem-end rot has been given it. Other decays follow injuries to the fruit, blue mold being rather common.

The *Diplodia* fungus is present in the orchards, and it may be introduced by the clippers used in harvesting the fruit. On this account the disinfection of the clippers after each fruit is cut from the tree is recommended. This can readily be done by wiping the clippers with a cloth saturated with a corrosive sublimate solution. Sealing with shellac the cut end of the stem or the cavity where the fruit is pulled from the stem has reduced stem-end rot to a considerable extent. Fruit that has been disinfected and shellacked as above described can be kept at room temperatures without developing stem-end rot until it dries up.

Some experimental data were obtained on the proper temperature and ventilation for the shipment of grapefruit, but the problems connected with the commercial handling of the fruit between the orchards in Porto Rico and the market in New York have not yet been solved.

Shipping miscellaneous tropical fruits.—As a result of the investigations on the handling of citrus fruit, a study of the keeping and shipping qualities of other tropical fruits was undertaken during the year. This study will be continued as one of the main projects of the coming year.

AGRICULTURAL EXTENSION NOTES.

Timely information dealing with agricultural subjects continued to be published in the form of Agricultural Extension Notes. Five of the numbers issued dealt with fruits, vegetables, and food crops in general. The others were concerned with ornamentals, cane, coffee, mosquitoes, lime and its uses, and live stock.



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